TITLE: SUBSTRATE DIVIDING SYSTEM, SUBSTRATE MANUFACTURING EQUIPMENT, SUBSTRATE SCRIBING METHOD AND SUBSTRATE DIVIDING METHOD

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TECHNICAL FIELD

[0001] The present invention relates to a substrate cutting system used for cutting a mother substrate made of a variety of materials including a mother substrate (e.g., a glass substrate used as a display panel for a liquid crystal display device, etc). In particular, the present invention relates to a substrate cutting system, a substrate manufacturing apparatus, a substrate scribing method and a substrate cutting method preferably used for cutting a bonded mother substrate for which a pair of brittle material substrates is bonded to each other.

BACKGROUND ART

[0002] Normally, a display panel for a liquid crystal display device, etc is formed with a glass substrate which is a brittle material substrate. In the liquid crystal display device, the display panel is fabricated by bonding a pair of glass substrates with an appropriate space formed therebetween and thereafter, injecting a liquid crystal in the space therebetween.

[0003] When such a display panel is fabricated, a bonded mother substrate for which a pair of mother substrates is bonded to each other is cut so as to retrieve a plurality of display panels from the bonded mother substrate. A scribing device used for cutting the bonded mother substrate is disclosed in Japanese Utility Model Publication for Opposition No. 59-22101 (Reference 1).

[0004] Figure **43** shows a view schematically showing the scribing device in Reference 1. The scribing device **950** includes tables **951** having side edges on both sides of a bonded mother substrate **908** mounted thereon, respectively. A clamp member **952** is attached to the table **951** for clamping each side edge of the bonded mother substrate **908**. The scribing device **950** includes a pair of cutter heads **953** and **954**. The cutter heads **953** and **954** are provided above and below the bonded mother substrate **908** respectively. The cutter heads **953** and **954** are in a state of facing each other with the bonded mother substrate **908** therebetween.

[0005] In the scribing device **950** having such a structure, when the bonded mother substrate **908** is fixed to each table **951** by each clamp member **952**, a top surface and a bottom surface of the bonded mother substrate **908** are simultaneously scribed, respectively, by the pair of cutter heads **953** and **954,** and scribing lines are formed.

[0006] Reference 1: Japanese Utility Model Publication for Opposition No. 59-22101

DISCLOSURE OF THE INVENTION

[0007] However, the scribing device **950** requires a breaking device, separately, for cutting the bonded mother substrate **908** on which the scribing lines have been formed. Also, when the bonded mother substrate **908** is cut by the breaking device, it is necessary to invert the bonded mother substrate **908** (inverting such that the upper surface of the bonded mother substrate **908** becomes the lower surface) in order to cut the mother substrate on the other side of the bonded mother substrate **908** after the mother substrate on one side of the bonded mother substrate **908** is cut. Thus, in order to cut display panels from the bonded mother substrate **908**, a complex line system has to be constructed.

[0008] In order to cut display panels from the bonded mother substrate **908** by using the scribing device **950**, a complex line system has to be constructed. The complex system has a footprint area several times larger than the scribing device **950**, which is one of the reasons of the manufacturing cost of display panel increases.

[0009] The scribing device **950** shown in Figure **43** simultaneously scribes the top and bottom surfaces of the bonded mother substrate **908** for which a pair of mother substrate is bonded. However, the direction of scribing is limited to only one direction (left-to-right direction in the figure) and therefore, a cross scribing (scribing in a direction perpendicular to a scribing line(vertical direction in the figure)) can not be performed.

[0010] Accordingly, another scribing device is further required in order to perform a cross scribing. Therefore, a problem exists that the efficiency of scribing the bonded mother substrate **908** is extremely poor.

[0011] Even when a variety of mother substrates are simultaneously cut from the top and bottom surfaces of the substrate by using a device similar to the aforementioned scribing device **950**, there is a problem that with one setting for a substrate, a process can not be performed in two directions perpendicular to each other.

[0012] The present invention is made to solve the aforementioned problems. The objective of the present invention is to provide a substrate cutting system which requires a small footprint area so as to be compact, and also which is capable of efficiently cutting a substrate.

[0013] A substrate cutting system according to the present invention includes: a mounting base having a substrate supporting device for supporting a substrate; clamp devices for holding at least one part of a side edge of the substrate carried-in

on the table, the clamp devices reciprocating the substrate along the Y direction, the Y direction being along one side of the mounting base; a pair of substrate cutting devices for cutting both sides of the substrate, respectively; and substrate cutting device guide bodies, fixed to the mounting base facing each other, for moving each of the substrate cutting devices on a top surface side and a bottom surface side of the substrate in the X direction perpendicular to the Y direction, the substrate being moved in the Y direction by the clamp devices, wherein the substrate supporting device further includes first substrate supporting units and second substrate supporting units, the first substrate supporting units and the second substrate supporting units are apart from each other in the Y direction and arranged with the substrate cutting devices therebetween, and the first substrate supporting units and the second substrate supporting units support the substrate such that the substrate which has been moved in the Y direction by the clamp devices is cut along the X direction and the Y direction by the substrate cutting devices.

[0014] The first substrate supporting units and the second substrate supporting units support the substrate without rubbing against the substrate when the clamp devices moves while holding the substrate.

[0015] The first substrate supporting units and the second substrate supporting units are structured by conveyor belts, respectively, the conveyor belts being rotary-driven in the moving direction of the clamp devices at the same speed as that when the clamp devices move while holding the substrate.

[0016] The substrate cutting devices include a cutter wheel for forming a scribing line on the substrate; and a cutter head having a servo motor for transmitting a pressure force against the substrate to the cutter wheel.

[0017] A substrate cutting system according to the present invention further includes: a steam unit section for spraying steam onto the top surface and the bottom surface of the substrate, on both of which the scribing line is scribed.

[0018] A substrate drying means is provided in the steam unit section, the substrate drying means for drying the top surface and the bottom surface of the substrate.

[0019] A substrate cutting system according to the present invention further includes a substrate carry-out device for retrieving the substrate cut by the steam unit section.

[0020] The substrate carry-out device includes a carry-out robot, the carry-out robot including: a substrate holding means for holding the substrate; a substrate rotating means for rotating the substrate holding means having the substrate held thereby about a first axis vertical to the substrate; and a substrate circling means for circling the substrate rotating means around a second axis, the second axis being different from the first axis vertical to the substrate held by the substrate holding means.

[0021] A substrate cutting system according to the present invention further includes a substrate inversion means for inverting the top surface and the bottom surface of the substrate transported by the substrate transportation device.

[0022] A substrate cutting system according to the present invention further includes a positioning unit section for positioning the substrate to be transported to the substrate supporting device.

[0023] A substrate cutting system according to the present invention further includes a transportation unit for transporting the substrate to the substrate drying means, the substrate having been scribed by the substrate cutting device.

[0024] A substrate cutting system according to the present invention further includes a removal means for removing an unnecessary portion of the substrate cut by the substrate cutting devices.

[0025] The substrate is a bonded mother substrate for which a pair of mother substrates is bonded to each other.

[0026] A substrate cutting system according to the present invention includes: a mounting base having a substrate supporting device for supporting a substrate; clamp devices for holding at least one part of a side edge of the substrate carried-in on the table and reciprocating the substrate along the Y direction, the Y direction being along one side of the mounting base; a pair of substrate cutting devices for cutting both side of the substrate, respectively; and substrate cutting device guide bodies, fixed to the mounting base facing each other, for moving each of the substrate cutting devices on a top surface side and a bottom surface side of the substrate in the X direction perpendicular to the Y direction, the substrate being moved in the Y direction by the clamp devices, wherein the substrate supporting device further includes first substrate supporting units and second substrate supporting units, the first substrate supporting units and the second substrate supporting units are apart from each other in the Y direction and arranged with the substrate cutting devices therebetween, and the substrate cutting system further includes substrate floating units for supporting the substrate with air, the substrate being clamped by the clap devices when the substrate which has been moved by the clamp devices in the Y direction is cut by the substrate cutting devices along the X direction and the Y direction.

[0027] The substrate floating units include first substrate floating units arranged within the first substrate supporting section and second substrate floating units arranged within the second substrate supporting section.

[0028] The first substrate supporting units and the second substrate supporting units include a plurality of conveyor belts arranged along the Y direction, respectively, and the first substrate floating units and the second substrate floating units are arranged between the conveyor belts adjacent to each other.

[0029] The first substrate floating units and the second substrate floating units respectively include a table arranged between the conveyor belts adjacent to each other; and an air gushing means for gushing air upward from the top surface of the table.

[0030] The air gushing means includes a plurality of air gushing rods supported by the table in a vertical state; and a buffer pad provided at the upper end of each of the air gushing rods wherein an air gushing opening is provided at each buffer pad.

[0031] A substrate manufacturing apparatus according to the present invention includes: the substrate cutting system; and a chamfering system for chamfering an edge face of a substrate cut by the substrate cutting system.

[0032] A substrate manufacturing apparatus according to the present invention includes: the substrate cutting system; and an inspection system for inspecting the function of a substrate cut by the substrate cutting system.

[0033] A substrate scribing method according to the present invention is a scribing method for forming scribing lines on the a surface and a bottom surface of a substrate by using the substrate cutting system, wherein when at least two scribing lines are formed along at least two lines to be scribed on the substrate with scribing line forming means facing each other, the scribing line forming means forms a first

scribing line, then moves on the substrate so as to draw a circular region without being apart from the substrate and then forms a second scribing line.

[0034] Three or more scribing lines are formed by the scribing line forming means and a polygonal region is formed by all the formed scribing lines.

[0035] A rectangular region is formed by the scribing lines.

[0036] The scribing line forming means is a disk-shaped cutter wheel, a blade edge contacting and rolling on the surface of the substrate being formed on the outer circumference of the scribing line forming means.

[0037] A plurality of protrusions is formed on the blade edge of the cutter wheel with a predetermined pitch.

[0038] When the scribing line forming means moves on the substrate so as to draw a circular track, a pressure against the substrate is less than a pressure against the substrate when each scribing line is formed.

[0039] A substrate cutting method according to the present invention includes the steps of: forming a main scribing line along a line to be cut on the upper surface and the lower surface of a substrate by using the substrate cutting system; and forming a supplementary scribing line proximal to the formed main scribing line and approximately in parallel with the main scribing line, wherein the substrate is cut along the main scribing line by formation of the supplementary scribing line.

[0040] The supplementary scribing line is formed with a space of 0.5 mm to 1.0 mm apart from the main scribing line.

[0041] The main scribing line is formed by a vertical crack which extends to at least 80% or more of the thickness direction of the substrate from a surface of the substrate.

[0042] The main scribing line is formed by a disk-shaped cutter wheel which rolls on the surface of the substrate, the cutter wheel protrudes outward such that the central portion of the outer circumferential face of the cutter wheel in the thickness direction has an obtuse V shape, a plurality of protrusions with a predetermined height is provided across the entire circumference with a predetermined pitch in portions having the obtuse angle.

[0043] A forming direction of the main scribing line and a forming direction of the supplementary scribing line by the cutter wheel are opposite to each other, and the cutter wheel continuously forms the main scribing line and the supplementary scribing line while being in contact with the surface of the substrate.

[0044] The main scribing line and/or the supplementary scribing line is formed with an appropriate space apart from at least one end portion of either of the lines.

[0045] When at least two main scribing lines are formed by the scribing line forming means, the scribing line forming means forms a first main scribing line, then moves on the substrate so as to draw a circular region without being apart from the substrate, forms a second main scribing line and then forms supplementary scribing lines along the at least two main scribing lines.

[0046] Three or more main scribing lines are formed by the scribing line forming means and a polygonal region is formed by all the formed scribing lines.

[0047] A rectangular region is formed by the plurality of main scribing lines.

[0048] The scribing line forming means is a disk-shaped cutter wheel, a blade edge contacting and rotating on the surface of the substrate being formed on the outer circumference of the scribing line forming means.

[0049] A plurality of protrusions is formed on the blade edge of the cutter wheel with a predetermined pitch.

[0050] When the scribing line forming means moves on the substrate so as to draw a circular track, a pressure against the substrate is less than a pressure against the substrate when each main scribing line is formed.

[0051] A substrate cutting method according to the present method is a method for cutting a substrate in which a scribing line is formed on each of the upper surface and the lower surface of the substrate by using the substrate cutting system according, wherein steam is sprayed onto the upper surface and the lower surface of the substrate so as to cut the substrate.

[0052] According to the substrate cutting system of the present invention, the substrate supported by the first substrate supporting units and the second substrate supporting units is moved in the Y direction while being held by the clamp devices; the substrate being moved can be cut in the X direction from the upper surface side and the lower surface side of the substrate by the substrate cutting device; and then, the substrate supported by the first substrate supporting units and the second substrate supporting units is reciprocated in the Y direction while being held by the clamp devices; and the substrate being moved can be cut in the Y direction from the upper surface side and the lower surface side of the substrate by the substrate cutting device. Therefore, it is possible to continuously cut single-plate substrates of both top and bottom surfaces forming the bonded substrate in two directions perpendicular to each other in a horizontal direction without the bonded substrate being inverted in the up-and-down direction or being rotated by 90 degrees in the horizontal direction. Thus, the entire system becomes compact and it is possible to continuously process in two directions with one setting, such as positioning.

[0053] The first substrate supporting units and the second supporting units support the substrate without each unit rubbing against the substrate when the clamp

devices move while holding the substrate. Thus, when the clamp devices move in the Y direction while holding the substrate supported by the first substrate supporting units and the second substrate supporting units, the clamp devices move without loading any distortion stress on the substrate, thereby the substrate having a strong end face being stably obtained.

BRIEF DESCRIPTION OF THE DRAWINGS

[0054] Figure **1** is a perspective view schematically showing an example of a substrate cutting system according to Embodiment 1 of the present invention.

[0055] Figure **2** is a perspective view schematically showing the substrate cutting system when viewed from another direction.

[0056] Figure **3** is a perspective view schematically showing enlargement of important constituents of the substrate cutting system.

[0057] Figure **4** is a perspective view schematically showing enlargement of other important constituents of the substrate cutting system.

[0058] Figure **5(a)** is a diagram schematically showing the structure of the carry-out robot of the substrate carry-out device; and Figure **5(b)** is a view for explaining the operation of the carry-out robot.

[0059] Figure **6** is a side view showing a first substrate supporting unit provided on the substrate carry-out device of the substrate cutting system.

[0060] Figure **7** is a front view showing a first substrate supporting section when viewed from a cutting device guide body's side of the substrate cutting system.

[0061] Figure **8** is a front view of important constituents when a steam unit section of the substrate cutting system according to Embodiment 1 of the present invention is viewed from the substrate carry-in side.

[0062] Figure **9** is a side-sectional view partially showing the structure of a steam unit of the steam unit section.

[0063] Figure **10** is a perspective view showing the structure of a clamp device provided in the substrate cutting system according to Embodiment 1 of the present invention and explaining the operation thereof.

[0064] Figure **11** is a perspective view showing the structure of a clamp device provided in the substrate cutting system according to Embodiment 1 of the present invention and explaining the operation thereof.

[0065] Figure **12** is a side view showing an example of a cutter head provided in the substrate cutting device of the substrate cutting system according to Embodiment 1 of the present invention.

[0066] Figure **13** is a front view showing important constituents of the cutter head.

[0067] Figure **14** is a front view showing another example of the cutter head provided in the substrate cutting device of the substrate cutting system according to Embodiment 1 of the present invention.

[0068] Figure **15** is a schematic plan view for explaining the operation of the substrate cutting system according to Embodiment 1 of the present invention.

[0069] Figure **16** is a schematic plan view for explaining the operation of the substrate cutting system according to Embodiment 1 of the present invention.

[0070] Figure **17** is a view showing a scribing pattern when a substrate is scribed in the substrate cutting system according to Embodiment 1 of the present invention.

[0071] Figure **18** is a view showing another scribing pattern when the substrate is scribed in the substrate cutting system according to Embodiment 1 of the present invention.

[0072] Figure **19** is a view showing yet another scribing pattern when the substrate is scribed in the substrate cutting system according to Embodiment 1 of the present invention.

[0073] Figure **20** is a schematic plan view for explaining the operation of the substrate cutting system according to Embodiment 1 of the present invention.

[0074] Figure **21** is a schematic plan view for explaining the operation of the substrate cutting system according to Embodiment 1 of the present invention.

[0075] Figure **22** is a sectional view of the substrate for explaining the principle of a substrate cutting method according to the present invention.

[0076] Figure **23** is a plan view of the substrate showing a scribing pattern of the substrate for explaining an example of the substrate cutting method according to the present invention.

[0077] Figure **24** is a plan view of the substrate showing a scribing pattern of the substrate for explaining another example of the substrate cutting method according to the present invention.

[0078] Figure **25** is a partial plan view of the substrate showing a scribing pattern of the substrate for explaining yet another example of the substrate cutting method according to the present invention.

[0079] Figure **26(a)** is a plan view of the substrate showing a scribing pattern of the substrate for explaining yet another example of the substrate cutting method according to the present invention; and Figure **26(b)** is a plan view of the substrate showing a scribing pattern of the substrate for explaining yet another example of the substrate cutting method according to the present invention.

[0080] Figure **27** is a plan view of the substrate showing a scribing pattern of the substrate for explaining yet another example of the substrate cutting method according to the present invention.

[0081] Figure **28** is a partial plan view of the substrate showing a scribing pattern of the substrate for explaining yet another example of the substrate cutting method according to the present invention.

[0082] Figure **29** is a plan view of the substrate showing a scribing pattern of the substrate for explaining yet another example of the substrate cutting method according to the present invention.

[0083] Figure **30** is a plan view for explaining yet another example of the substrate cutting method according to the present invention.

[0084] Figure **31** is a plan view of the substrate showing a scribing pattern of the substrate for explaining yet another example of the substrate cutting method according to the present invention.

[0085] Figure **32** is a perspective view schematically showing an example of an entire substrate cutting system according to Embodiment 2 of the present invention in whole.

[0086] Figure **33** is a plan view schematically showing the substrate cutting system.

[0087] Figure **34** is a side view schematically showing the substrate cutting system.

[0088] Figure **35** is a perspective view schematically showing a positioning unit section of the substrate cutting system according to Embodiment 2 of the present invention.

[0089] Figure **36** is a schematic view for explaining a panel terminal separation section of the substrate cutting system according to Embodiment 2 of the present invention.

[0090] Figure **37** is a partial schematic plan view for explaining the operation of the substrate cutting system according to Embodiment 2 of the present invention.

[0091] Figure **38** is a partial schematic plan view for explaining the operation of the substrate cutting system according to Embodiment 2 of the present invention.

[0092] Figure **39** is a partial schematic plan view for explaining the operation of the substrate cutting system according to Embodiment 2 of the present invention.

[0093] Figure **40** is a partial schematic plan view for explaining the operation of the substrate cutting system according to Embodiment 2 of the present invention.

[0094] Figure **41** is a view schematically showing an example of the structure of a substrate manufacturing apparatus according to the present invention in Embodiment 3.

[0095] Figure **42** is a view schematically showing another example of the structure of a substrate manufacturing apparatus according to the present invention in Embodiment 3.

[0096] Figure **43** is a front view showing the structure of a conventional scribing device.

[0097] Figure **44** is a plan view schematically showing a substrate cutting system according to Embodiment 4 of the present invention.

[0098] Figure **45** is a plan view schematically showing a first substrate floating unit in the substrate cutting system.

[0099] Figure **46** is a side view showing the first substrate floating unit.

[00100] Figure **47** is a longitudinal-sectional view of the first substrate floating unit.

[00101] Figure **48** is a longitudinal-sectional view for explaining the operation of the first substrate floating unit.

[00102] **10** mounting base

[00103]	**20**	substrate supporting section
[00104]	**20A**	first substrate supporting section
[00105]	**20B**	second substrate supporting section
[00106]	**21A**	first substrate supporting unit
[00107]	**21B**	second substrate supporting unit
[00108]	**29A**	first substrate floating unit
[00109]	**29B**	second substrate floating unit
[00110]	**30**	substrate cutting device guide body
[00111]	**50**	clamp device
[00112]	**60**	upper substrate cutting device
[00113]	**70**	lower substrate cutting device
[00114]	**80**	substrate carry-out device
[00115]	**90**	bonded mother substrate
[00116]	**220**	positioning unit section
[00117]	**240**	scribing unit section
[00118]	**241A**	first substrate supporting section
[00119]	**241B**	second substrate supporting section
[00120]	**244A**	first substrate supporting unit
[00121]	**244B**	second substrate supporting unit
[00122]	**260**	buffer conveyor section
[00123]	**280**	steam break unit section
[00124]	**300**	substrate transportation unit section
[00125]	**320**	panel inversion unit section
[00126]	**340**	panel terminal separation section

BEST MODE FOR CARRYING OUT THE INVENTION

[00127] Hereinafter, embodiments of the present invention will be described in detail with reference to the drawings.

EMBODIMENT 1

[00128] Figures **1** and **2** are perspective views entirely and schematically showing one example of a substrate cutting system according to the present invention. Figures **1** and **2** are viewed from different directions. In the present invention, the term "substrate" includes a single plate, such as a mother substrate cut into a plurality of substrates, a metal substrate (e.g., a steel plate), a wood plate, a plastic plate and a brittle material substrate (e.g., a ceramic substrate, a semiconductor substrate and a glass substrate). However, the substrate according to the present invention is not limited to such a single plate. The substrate according to the present invention may include a bonded substrate for which a pair of substrates is bonded to each other and a stacked substrate for which a pair of substrates is stacked on each other.

[00129] In the substrate cutting system in the present invention, for example, when a panel substrate (bonded substrate for display panel) for a liquid crystal device is manufactured from a pair of glass substrates bonded to each other, a plurality of panel substrates (bonded substrate for display panel) are cut, by the substrate cutting system according to the present invention, from the bonded mother substrate **90** for which a pair of mother glass substrates is bonded to each other.

[00130] In a substrate cutting system **1** according to Embodiment 1 of the present invention, description will be made by referring to the side where a first substrate supporting section **20A** is arranged, as a "substrate carry-in side" and the side where a substrate carry-out device **80** is arranged, as a "substrate carry-out side",

respectively. In the substrate cutting system **1** according to the present invention, the direction in which a substrate is transported (flow direction of the substrate) is +Y direction from the substrate carry-in side to the substrate carry-out side. The cutting device guide body **30** is provided in a horizontal state along the X direction which is perpendicular to the direction in which the substrate is transported.

[00131] The substrate cutting system **1** includes a mounting base **10** in a hollow rectangular parallelepiped. Four pillars **14** are provided on the upper surface of the mounting base **10**. A main frame **11** having a frame shape is provided at the top portion of the pillars **14**. A substrate supporting device **20** is arranged on the upper surface of the mounting base **10**. The substrate supporting device **20** supports the bonded mother substrate **90** in a horizontal state, the bonded mother substrate **90** being transported to the substrate cutting system **1** by a transportation robot.

[00132] As shown in Figure **1**, the substrate supporting device **20** includes a first substrate supporting section **20A** and a second substrate supporting section **20B**. The first substrate supporting section **20A** is arranged on the substrate carry-in side of the substrate cutting system **1** in order to support the bonded mother substrate **90** which is carried onto the main frame **11**. The second substrate supporting section **20B** is arranged on the substrate carry-out side in order to support the bonded mother substrate **90** after the bonded mother substrate **90** is cut and display panels are sequentially carried out from the substrate cutting system. The first substrate supporting section **20A** side in the mounting base **10** is referred to as a substrate carry-in side. The second substrate supporting section **20B** side in the mounting base **10** is referred to as a substrate carry-out side.

[00133] As shown in Figure **2**, above the mounting base **10**, clamp devices **50** which hold the substrate in a horizontal state, the substrate being supported in a horizontal

state by the substrate supporting device **20** (first substrate supporting unit **21A**) are provided so as to be slidable along frames **11A** and **11B** in a longitudinal direction of the main frame **11**. Furthermore, as shown in Figure **1**, a cutting device guide body **30** is provided between the first substrate supporting section **20A** and the second substrate supporting section **20B** on the top surface of the mounting base **10**, the first substrate being fixed by each of the pillars **33** along a direction in a horizontal state is perpendicular to a direction in which the substrate is transported. The cutting device guide body **30** includes an upper guide rail **31** above the main frame **11** and a lower guide rail **32** below the main frame **11**. The upper guide rail **31** is constructed along the X direction which is perpendicular to the frames **11A** and **11B** in the longitudinal direction of the main frame **11**. The lower guide rail **32** is constructed along the upper guide rail **31.**

[00134] Figure **3** is a perspective view schematically showing the vicinity of the upper guide rail **31** of the cutting device guide body **30**. An upper substrate cutting device **60** is attached to the upper guide rail **31** so as to be movable along the upper guide rail **31**. Figure **4** is a perspective view schematically showing the vicinity of the lower guide rail **32** of the cutting device guide body **30**. A lower substrate cutting device **70** is attached to the lower guide rail **32** so as to be movable along the lower guide rail **32**.

[00135] The upper substrate cutting device **60** and the lower substrate cutting device **70** reciprocate along the upper guide rail **31** and the lower guide rail **32**, respectively, due to linear motors. Stators for the linear motors are attached to the upper guide rail **31** and the lower guide rail **32**. Movers for the linear motors are attached to the upper substrate cutting device **60** and the lower substrate cutting device **70**. The upper substrate cutting device **60** and the lower substrate cutting

device **70** cut each glass substrate on the upper and lower sides of the bonded mother substrate **90** into a plurality of display panels, the bonded mother substrate **90** being held in a horizontal state by the clamp devices **50** and supported by the substrate supporting device **20** to provide assistance in holding the bonded mother substrate **90**.

[00136] As shown in Figure **2,** a first optical device **38** is provided at one end of the cutting device guide body **30** so as to be movable along the cutting device guide body **30.** The first optical device **38** captures a first alignment mark provided on the bonded mother substrate **90** which is held by the clamp devices **50** and supported by the substrate supporting device **20.** A second optical device **39** is provided at the other end of the cutting device guide body **30** so as to be movable along the cutting device guide body **30.** The second optical device **39** captures a second alignment mark provided on the bonded mother substrate **90.**

[00137] As shown in Figures **1** and **2**, end surfaces of the upper guide rail **31** and the lower guide rail **32** are connected to each other via each of the pillars **33**, and both ends of the cutting device guide body **30** are fixed on the top surface of the mounting base **10** by each of the pillars **33**.

[00138] Above the substrate carry-out side of the mounting base **10,** the substrate carry-out device **80** is arranged on the substrate carry-out side with respect to the cutting device guide body **30**. The substrate carry-out device **80** includes a carry-out robot **140** and a substrate carry-out device guide **81**. The carry-out robot **140** carries out each display panel that has been cut from the bonded mother substrate **90**. The substrate carry-out device guide **81** is constructed in order to move the carry-out robot **140** in the X direction which is perpendicular to the frames **11A** and **11B** in the longitudinal direction of the main frame **11**. Ends of the substrate carry-

out device guide **81** slide, by linear motors, along the guide rails **13** respectively provided on the top surface of the mounting base **10** through supporting members **82.**

[00139] Stators **12** for the linear motors are provided on the upper surface of the mounting base **10** along the frames **11A** and **11B** in the longitudinal direction of the main frame **11.** The linear motors having the stators **12** move the substrate carry-out device **80**. Each stator **12** is formed in a shape of a flat and hollow rectangular parallelepiped, the outside surface thereof being open. The cross section thereof is formed in a shape of "ㅋ". Movers (not shown) for the linear motors are inserted in each of the stators, respectively, the movers being provided on each of the guide bases **16** respectively holding the pillars **82** which support both ends of the substrate carry-out device **80.** The movers are slidable along the frames **11A** and **11B** in the longitudinal direction of the main frame **11.**

[00140] A plurality of permanent magnets is arranged on each stator **12** along the longitudinal direction of the main frame **11**. Magnetic poles of adjacent permanent magnets are in a state opposed to each other. Each mover is constructed with an electromagnet. When the magnetic pole of the electromagnet which constitutes each mover is sequentially changed, each mover slides along each stator **12**.

[00141] An adsorption section (not shown) is provided on the carry-out robot **140** of the substrate carry-out device **80.** The adsorption section adsorbs each display panel cut from the bonded mother substrate **90** by suction. While each display panel is in a state of being adsorbed by the adsorption section, the entire substrate carry-out device **80** is slid to the substrate carry-out side and each cut display panel is carried out from the mounting base **10**.

[00142] Figure **5(a)** is a diagram schematically showing the structure of the carry-out robot **140** of the substrate carry-out device **80**. The carry-out robot **140** is attached to the substrate carry-out device guide **81**. The carry-out robot **140** is movable by a moving mechanism in a direction (X direction) along the substrate carry-out device guide **81.** The moving mechanism combines a driving means due to a linear motor or a servo motor, and a straight-line guide.

[00143] The carry-out robot **140** includes two servo motors **140a** and **140m.** The servo motor **140a** is connected to a driving shaft **140b.** A first pulley **140c** and a second pulley **140e** are integrally attached to each other and are attached to the driving shaft **140b** via a bearing. When the driving shaft **140b** is rotated, the first pulley **140c** and the second pulley **140e** detach from the driving shaft **140b.** An end of an arm **140f** is integrally attached to the driving shaft **140b.** The arm **140f** rotates with the driving shaft **140b** as its center due to the rotation of the driving shaft **140b.** A rotating shaft **140g** is supported on the tip of the arm **140f** so as to be rotatable. The rotating shaft **140g** penetrates the arm **140f.** A third pulley **140h** is integrally attached to one end of the rotating shaft **140g.** For example, a belt (e.g., a timing belt **141i**) is wound around the second pulley **140e** and the third pulley **140h.**

[00144] Furthermore, a fourth pulley **140n** is attached to the rotating axis of the servo motor **140m.** For example, a belt (e.g., a timing belt **141p**) is wound around the fourth pulley **140n** and the first pulley **140c.** Therefore, the rotation of the servo motor **140m** is transmitted to the first pulley **140c** through the belt **140p** and is further transmitted to the third pulley **140h** through the belt **140i**. As a result, the rotating shaft **140g** rotates.

[00145] The central portion of an adsorption pad attachment plate **140j** is integrally attached to the other end of the rotating shaft **140g.** Adsorption pads **140k,** which

adsorb a substrate, by using an adsorption mechanism (not shown), cut by the substrate cutting system **1** are provided on the bottom surface of the adsorption pad attachment plate **140j.**

[00146] . When the carry-out robot **140** having such a structure is set using the combination of the rotating direction and the rotating angle of each servo motor **140a** and **140m**, the cut substrate can be carried out to an device for the next step while minimizing the distance moved by the arm **140f** and maintaining the direction of the cut substrate being at a horizontal state or being changed to a variety of angle directions.

[00147] In the transportation of the cut substrate, the cut substrate is held by the adsorption of the adsorption pad. After the entire carry-out robot **140** is moved upward by an up-and-down moving mechanism (not shown) once, the cut substrate is transported to the device for the next step. Thereafter, the carry-out robot **140** is moved downward by the up-and-down moving mechanism (not shown) again and then, the cut substrate is mounted at a predetermined position in a predetermined state in the next step.

[00148] Next, the case in which the direction of the cut substrate is, for example, changed by 90 degrees by using the carry-out robot **140** having such a structure will be described with reference to Figure **5(b)**.

[00149] When each adsorption pad **140k** attached to the adsorption pad attachment plate **140j** adsorbs the cut substrate **93**, the entire carry-out robot **140** moves upward by the up-and-down moving mechanism. As a result, the servo motor **140a** is driven and the driving shaft **140b** is rotated by 90 degrees, the rotation direction of the driving shaft **140b** being anti-clockwise when viewed from the substrate side. When the driving shaft **140b** is rotated by 90 degrees, the arm **140f** is rotated by 90

degrees with the driving shaft **140b** as its center of rotation, the rotation direction of the arm **140f** being anti-clockwise when viewed from the substrate side. As a result, the adsorption pad attachment plate **140j** is rotated, along with the arm **140f**, by 90 degrees with the driving shaft **140b** as its center of rotation. The adsorption pad attachment plate **140j** being rotatably supported by the tip of the arm **140f** through the rotating shaft **140g** and the rotation direction of the adsorption pad attachment plate **140j** being anti-clockwise when viewed from the substrate side. In this case, the rotating shaft **140g** attached to the adsorption pad attachment plate **140j** is rotated with the driving shaft **140b** as its center of rotation.

[00150] Concurrently, the rotation of the servo motor **140m** is transmitted to the first pulley **140c** through the belt **140p** and is further transmitted to the third pulley **140h** through the belt **140i**. As a result, the rotating shaft **140g** is rotated by 180 degrees clockwise. The adsorption pad attachment plate **140j,** attached to the rotating shaft **140g**, rotates by 180 degrees clockwise with the rotating shaft **140g** as its center of rotation. Therefore, while the adsorption pad attachment plate **140j** rotates by 90 degrees with the driving shaft **140d** as its center of rotation, the rotation direction of the adsorption pad attachment plate **140j** is anti-clockwise when viewed from the substrate side, and the adsorption pad attachment plate **140j** rotates by itself by 180 degrees clockwise, when viewed from the substrate side, with the rotating shaft **140g** as its center. As a result, as shown in Figure **5(b),** the cut substrate **93** adsorbed by each adsorption pad **140k** is rotated, within a relatively small space, by 90 degrees clockwise when viewed from the substrate side while rotating around the center of the rotation.

[00151] As shown in Figure **1**, the first substrate supporting section **20A** and the second substrate supporting section **20B** of the substrate supporting device **20**

include, for example, five first substrate supporting units **21A** and five second substrate supporting units **21B**, respectively, which are provided, along the Y direction, on both sides of the Y direction with respect to the cutting device guide body **30**, respectively. Each of the first substrate supporting units **21A** and each of the second substrate supporting units **21B** are fixed on the mounting base **10,** by each holding plate **45,** on the substrate carry-in side and the substrate carry-out side with respect to the cutting device guide body **30,** respectively, in line along a direction (Y direction) parallel to the frames **11A** and **11B** of the main frame **11**.

[00152] Figure **6** is a diagram showing a side view of one of the first substrate supporting units **21A** provided on the first substrate supporting section **20A**. Each of the first substrate supporting units **21A** is attached to the top surface of the mounting base **10** by the holding plate **45** and is provided above the mounting base **10.**

[00153] A plurality of first substrate supporting units **21A** (five in the explanation of the present embodiment) is arranged with a predetermined interval therebetween. The first substrate supporting units **21A** are attached to the top surface of the mounting base **10** by using the holding plates **45.**

[00154] The first substrate supporting unit **21A** includes a supporting body section **21a**, which linearly extends along a direction (Y direction) parallel to the main frame **11**. Timing pulleys **21c** and **21d** which, for example, guide a timing belt **21**e, are attached to each end of the supporting body section **21a**, respectively. The timing belt **21**e is caused to circle by the timing pulley **21b** which is rotated when a motor **116** is driven (the motor **116** will be described later).

[00155] The mechanism having such a structure which moves the timing belt **21**e of the first substrate supporting unit **21A** will be described with reference to Figure **7.**

Figure **7** is a front view when a plurality (five) of first substrate supporting units **21A** provided on the first substrate supporting section **20A** when viewed from the cutting device guide body **30**.

[00156] As shown in Figure **7**, each timing pulley **21b** for driving provided on the supporting body section **21a** of the first substrate supporting unit **21A** is coupled to a rotating driving shaft **49** which is provided in parallel to the X direction perpendicular to the frames **11A** and **11B** in the longitudinal direction of the main frame **11**. One end of the rotating driving shaft **49** is connected to the rotation axis of the motor **116** by using a coupling (not shown), and the timing pulley **21b** for driving of the first substrate supporting unit **21A** is rotated in accordance with the rotating direction of the rotation axis of the motor **116,** and the rotation of the timing pulley **21b** for driving causes the timing belt **21e** to circle.

[00157] The rotation direction of the rotation axis of the motor **116** is selected by a control section (not shown) for controlling the substrate cutting system according to the present invention.

[00158] As shown in Figure **1**, the second substrate supporting section **20B** of the substrate supporting device **20** include, for example, five second substrate supporting units **21B**, respectively, which are provided, along the Y direction, on both sides of the Y direction with respect to the cutting device guide body **30**, respectively. The structure of the second substrate supporting unit **21B** is similar to that of the first substrate supporting unit **21A**. The first substrate supporting units **21A** and the second substrate supporting units **21B** are fixed on the top surface of the mounting base **10,** by holding plates **45,** on the substrate carry-in side and the substrate carry-out side with respect to the cutting device guide body **30,** respectively, in line along a direction (Y direction) parallel to the frames **11A** and

11B of the main frame **11** such that the first substrate supporting units **21A** and the second substrate supporting units **21B** are attached on opposite sides with respect to the cutting device guide body **30** and attached in the opposite direction with respect to the Y direction.

[00159] As shown in Figure **1**, a steam unit section **160**, which is a substrate drying means, is arranged between the substrate carry-out side of the second substrate supporting section **20B** and the substrate carry-in side of the substrate carry-out device **80** above the substrate carry-out side of the mounting base **10**. The steam unit section **160** is provided in order to completely cut the bonded mother substrate **90** which has not been completely cut after the scribing.

[00160] Figure **8** is a front view of important constituents when the steam unit section **160** is viewed from the substrate carry-in side. As shown in Figure **8,** in the steam unit section **160**, an upper steam unit attachment bar **162** and lower steam unit attachment bar **163** are attached to a pillar **164** on the frame **11A** side and a pillar **164** on the frame **11B** side, respectively, along the X direction which is perpendicular to the frame **11A** and the frame **11B**. The upper steam unit attachment bar **162** attaches a plurality of steam units **161** for spraying steam onto the mother substrate on the upper side of the bonded mother substrate **90**. The lower steam unit attachment bar **163** attaches a plurality of steam units **161** for spraying steam onto the mother substrate on the lower side of the bonded mother substrate **90**.

[00161] The steam unit section **160** slides, by the linear motors, along the guide rails **13**, respectively, provided on the upper surface of the mounting base **10**.

[00162] As shown in Figure **1,** stators **12** for the linear motors are provided on the top surface of the mounting base **10** along the frames **11A** and **11B** in the longitudinal

direction of the main frame **11.** The linear motors having the stators **12** move the steam unit section **160**. Each stator **12** is formed in a shape of a flat and hollow rectangular parallelepiped, the outside surface thereof being open. The cross section of each stator is formed in a shape of " コ ". Movers (not shown) for the linear motors is are inserted in each of the stators, respectively, the movers being provided on each of the guide bases **17** respectively holding the pillars **164** which support both ends of the steam unit section **160**. The movers are slidable along the frames **11A** and **11B** in the longitudinal direction of the main frame **11.**

[00163] A plurality of permanent magnets is arranged on each stator **12** along the longitudinal direction of the main frame **11**. Magnetic poles of adjacent permanent magnets are in a state opposed to each other. Each mover is constructed with an electromagnet, respectively. When the magnetic pole of the electromagnet which constitutes each mover is sequentially changed, each mover slides along each stator **12**.

[00164] As shown in Figure **8**, six steam units **161** are attached to the upper steam unit attachment bar **162**. Six steam units **161** are attached to the lower steam unit attachment bar **163** with a gap GA with respect to the six steam units **161** on the upper steam unit attachment bar **162.** The gap GA is adjusted such that the bonded mother substrate **90** passes through the gap GA when the steam unit section **160** moves to the substrate carry-in side.

[00165] Figure **9** is a partial sectional view showing the structure of the steam unit **161**. The steam unit **161** is mostly structured with aluminum material. A plurality of heaters **161a** is imbedded in the steam unit **161** in a perpendicular direction. When an opening/closing valve (not shown) which automatically opens and closes is opened, water flows into the steam unit **161** from a water supplying opening **161b**.

Then, the supplied water is heated by the heaters **161a** and evaporates into steam. The steam is sprayed onto the surface of the mother substrate from a gushing opening **161d** through a duct hole **161c.**

[00166] An air knife **165** is provided on the carry-out side of the upper steam unit attachment bar **162**. The air knife **165** is provided for removing the moisture which remains on the surface of the bonded mother substrate **90** after the steam is sprayed onto the upper surface of the bonded mother substrate **90**.

[00167] A steam unit **161** and an air knife **165** similar to those attached to the upper steam unit attachment bar **162** are provided on the lower steam unit attachment bar **163**.

[00168] A positioning device (not shown) is provided on the mounting base **10**. The positioning device is provided for positioning the bonded mother substrate **90** supported by the first substrate supporting section **20A**. In the positioning device, for example, a plurality of positioning pins (not shown) are provided along the frame **11B** of the main frame **11** and along the direction perpendicular to the frame **11B** with a fixed interval therebetween, respectively. Pushers (not shown) are provided with respect to the positioning pins arranged along the frame **11B.** The pushers are provided to push the side edges of the bonded mother substrate **90** which face each positioning pin. Pushers (not shown) are provided with respect to the positioning pins arranged along the direction perpendicular to the frame **11B**. The pushers are provided to push the side edges of the bonded mother substrate **90** which face each positioning pin.

[00169] Alternatively, for example, when a positioning device for positioning the bonded mother substrate **90** is provided separately from the present substrate cutting system immediately before the bonded mother substrate **90** is transported to

the substrate cutting system according to the present invention, the positioning device in the present substrate cutting system can be omitted.

[00170] The positioning device in the present substrate cutting system is not limited to the positioning pins and pushers described above. Any device can be used as a positioning device as long as the device can fix the position of the bonded mother substrate **90** in the substrate cutting system.

[00171] Furthermore, as shown in Figure **1,** a plurality of clamp devices **50** is provided above the mounting base **10** supported by the first substrate supporting section **20A**. The plurality of clamp devices **50** are provided to clamp the bonded mother substrate **90** pushed and positioned by each positioning pin.

[00172] As shown in Figure **2**, in order to clamp the side edge of the positioned bonded mother substrate **90** on the substrate carry-in side, the plurality of clamp devices **50** is arranged with a fixed interval therebetween along a direction perpendicular to the frames **11A** and **11B** of the main frame **11** (in Figure **2**, two clamp devices are arranged as one example).

[00173] Each clamp device **50** includes a clamp member **51** for clamping the side edge of the mother substrate **90.** The clamp members **51** are attached to holding members **58** joined to rods **56** of cylinders **55,** which are attached to the movement base **57,** and are moved upward and downward due to the driving of the cylinders **55**.

[00174] Figures **10** and **11** are perspective views for showing a plurality of clamp members **51** provided on each of the clamp devices and explaining the operation thereof.

[00175] Each clamp member **51** has a structure similar to each other. The clamp member **51** includes a casing **51a** and a pair of upper and lower turning arm

sections **51b.** The turning arm section **51b** is attached to the casing **51a** so as to be turnable from the vertical state to the horizontal state. Each turning arm section **51b** can turn with one of the ends being the center. The ends which are the center of each turning are adjacent to each other. In a vertical state, the tip of the turning arm section **51b** positioned on the upper side is positioned above the center of the turning as shown in Figure **10.** In a vertical state, the tip of the turning arm section **51b** positioned on the lower side is positioned below the center of the turning as shown in Figure **10.** When each turning arm section **51b** turns by 90 degrees toward the bonded mother substrate **90** side, each turning arm section **51b** is in a horizontal state facing each other.

[00176] A clamp section **51c** is attached to the tip of each turning arm section **51b.** The clamp sections **51c** contact the top surface and the bottom surface of the bonded mother substrate **90**, respectively. Each clamp section **51c** is made of an elastic body. At the same time when each turning arm section **51b** is integrally turned from the vertical state to the horizontal state, each clamp member **51c** is turned from the horizontal state to the vertical state. When each turning arm section **51b** is turned to the horizontal state, the bonded mother substrate **90** is clamped by the clamp section **51c** attached to the tip of each turning arm section **51b** as shown in Figure **11**.

[00177] The clamp members **51** are integrally driven. When each side edge of the bonded mother substrate **90** is in a state of being clamped by the plurality of clamp members **51**, all of the clamp members **51** lower downward and then, the bonded mother substrate **90** is supported by the timing belts **21e** of the first substrate supporting section **20A**.

[00178] In the arrangement of the aforementioned clamp devices **50,** if the clamp devices **50** for holding the bonded mother substrate **90** are structured so as to be provided along the frame **11A** or the frame **11B** of the main frame **11,** the bonded mother substrate **90** can be supported without being damaged.

[00179] The structure of the aforementioned clamp devices **50** and the clamp members **51** only shows one example which is used in the substrate cutting system according to the present invention and is not limited to this. In other words, any structure can be used as long as the structure can grasp or hold the side edges of the bonded mother substrate **90.** For example, when the size of the substrate is small, the substrate can be held by clamping one part of the side edges of the substrate, thereby the substrate being cut without causing any defect to the substrate.

[00180] Again, referring back to Figures **1** and **2**, a pair of guide rails **28** is provided on the top surface of the mounting base **10** along the Y direction. Each of the clamp devices **50** is slid along the pair of guide rails **28**, by using linear motors, between two first substrate supporting units **21A** of the plurality of the first substrate supporting units **21A** (five in the description of the Embodiment) which are arranged with a predetermined interval therebetween, each of the two first substrate supporting units **21A** being arranged on either side of the plurality of the first substrate supporting units **21A.**

[00181] As shown in Figure **2,** stators **28** for the linear motors are provided on the top surface of the mounting base **10** along the frames **11A** and **11B** in the longitudinal direction of the main frame **11.** The linear motors having the stators **28** move a movement base **57** holding each of the clamp devices **50**. Each stator **28** is formed in a shape of a flat and hollow rectangular parallelepiped, the inside surface thereof

being open. The cross section of each stator **28** is formed in a shape of " コ ". Movers (not shown) for the linear motors are inserted in each of the stators, respectively, the movers being provided in the movement base **57** which holds each of the clamp devices. The movers are slidable along the frames **11A** and **11B** in the longitudinal direction of the main frame **11.**

[00182] A plurality of permanent magnets is arranged on each stator **28** along the longitudinal direction of the main frame **11**. Magnetic poles of adjacent permanent magnets are in a state opposed to each other. Each mover is constructed with an electromagnet. When the magnetic pole of the electromagnet which constitutes each mover is sequentially changed, each mover slides along each stator **28**.

[00183] The bonded mother substrate **90** is mounted on the first substrate supporting section **20A**. When the bonded mother substrate **90** is positioned, the bonded mother substrate **90** thus positioned is held by the clamping device **50,** and at the same time, is supported by each of the timing belts **21e** of the first substrate supporting unit **21A**.

[00184] In this state, cutting and scribing the bonded mother substrate **90** is started by the upper substrate cutting device **60** and the lower substrate cutting device **70** provided on the cutting device guide body **30**. While the cutting or the scribing is being performed, simultaneous to when each of the clamp devices **50** starts moving to the substrate carry-out side, the timing belts **21e** of the first substrate supporting units **21A** of the first substrate supporting section **20A** and the timing belts **21e** of the second substrate supporting units **21B** of the second substrate supporting section **20B** are circled, clockwise in Figure **1,** at the same moving speed as that of each of the clamp devices **50;** and simultaneous to when each of the clamp devices **50** starts moving to the substrate carry-in side, the timing belts **21e** of the first

substrate supporting units **21A** of the first substrate supporting section **20A** and the timing belts **21e** of the second substrate supporting units **21B** of the second substrate supporting section **20B** are circled, anti-clockwise in Figure **1,** at the same moving speed as that of each of the clamp devices **50.** The bonded mother substrate **90** being currently cut or scribed is supported, without being rubbed against the timing belts **21e**, by the timing belts **21e** of the first substrate supporting units **21A** of the first substrate supporting section **20A** and the timing belts **21e** of the second substrate supporting units **21B** of the second substrate supporting section **20B.**

[00185] In this manner, while each of the clamp devices **50** is moving, the timing belts **21e** of the first substrate supporting units **21A** of the first substrate supporting section **20A** and the timing belts **21e** of the second substrate supporting units **21B** of the second substrate supporting section **20B** are circled at the same speed as the moving speed of each of the clamp devices **50,** which holds the bonded mother substrate **90,** in the same direction as the moving direction of each of the clamp devices **50**. Thus, the bonded mother substrate **90** on the move is supported, without being rubbed against the timing belts **21e**, by the timing belts **21e** of the first substrate supporting units **21A** of the first substrate supporting section **20A** and the timing belts **21e** of the second substrate supporting units **21B** of the second substrate supporting section **20B.**

[00186] In a state in which the cutting of the bonded mother substrate **90** is completed, the bonded mother substrate **90** is supported by each timing belt **21e** of the second substrate supporting unit **21B** of the second substrate supporting section **20B.**

[00187] In a state in which the bonded mother substrate **90** is supported by each of timing belts **21e** of each second substrate supporting unit **21B**, the steam unit section **160** moves to the substrate carry-in side, sprays the steam onto the entire top and bottom surfaces of the bonded mother substrate **90** on which the scribing lines have been formed. As a result, the vertical cracks on the bonded mother substrate **90** are extended due to the thermal stress and the bonded mother substrate **90** is completely cut. At the same time, the moisture which remains on the top and bottom surfaces of the bonded mother substrate **90** is removed by the air knife **165** after the steam is sprayed on the bonded mother substrate **90**.

[00188] Thereafter, all of the display panels cut from the bonded mother substrate **90** on the timing belts **21e** of all the second substrate supporting units **21B** of the second substrate supporting section **20B** are carried out by the carry-out robot **140** of the substrate carry-out device **80**, thereby the substrate **90'** (portion to be discarded) being supported on the timing belts **21e** of the second substrate supporting units **21B**.

[00189] Next, the substrate carry-out device **80** and the steam unit section **160** move toward the end of the substrate carry-out side. Thereafter, the clamp member **51** of each clamp device **50** is open, and the state of the cut bonded mother substrate **90'** changed from being gripped by the clamp members **51** to being only supported by the timing belt **21e** of each of the second substrate supporting units **21B.**

[00190] When the cut bonded mother substrate **90'** is supported by the timing belt **21e** of each of the second substrate supporting units **21B**, each of the clamp devices **50** is caused to move toward the substrate carry-in side and the timing belts **21e** of all the second substrate supporting units **21B** of the second substrate supporting section **20B** are circled. Thus, the cut bonded mother substrate **90'**

(portion to be discarded) falls down. In this case, the cut bonded mother substrate **90'** (portion to be discarded or cullet) which has fallen is guided by a guide plate arranged in a slanted state so as to be accommodated into a cullet accommodation box.

[00191] An upper substrate cutting device **60,** as shown in Figure **3,** is attached to the upper guide rail **31** of the cutting device guide body **30.** A lower substrate cutting device **70**, as shown in Figure **4,** is attached to the lower guide rail **32**, the lower substrate cutting device **70** having a similar structure to the upper substrate cutting device **60** and being in a state of inversion to the upper substrate cutting device **60** in a vertical direction. As described above, the upper substrate cutting device **60** and the lower substrate cutting device **70** slide along the upper guide rail **31** and the lower guide rail **32**, respectively, due to linear motors.

[00192] A cutter head **65** using a servo motor is provided on the upper substrate cutting device **60** and the lower substrate cutting device **70**, respectively. Figure **12** shows a side view of the cutter head **65**. Figure **13** shows a front view of the important constituents of the cutter head **65**. For example, as shown in Figures **12** and Figure **13,** cutter wheels **62a** for scribing a bonded mother substrate **90** are rotatably attached to tip holders **62b**, respectively. Furthermore, the tip holders **62b** are rotatably attached to respective cutter heads **62c** with a direction vertical to top and bottom surfaces of the bonded mother substrate **90** held by the clamp devices **50** at its axis. The cutter heads **62c** are movable along a direction vertical to top and bottom surfaces of the bonded mother substrate **90** by a driving means (not shown). A load is applied to the cutter wheels **62a**, as appropriate, by an energizing means (not shown).

[00193] Regarding the cutter wheel **62a** held by the tip holder **62b**, a cutter wheel which has a blade edge with the center in the width direction protruded in an obtuse V shape is used as disclosed in Japanese Laid-Open Publication No. 9-188534. The protrusions with a predetermined height are formed on the blade edge with a predetermined pitch in the circumferential direction.

[00194] The lower substrate cutting device **70** provided on the lower guide rail **32** has a structure similar to the upper substrate cutting device **60**, but is provided in an inverted state thereto. The cutter wheel **62a** (see Figure **4**) of the lower substrate cutting device **70** is arranged so as to face the cutter wheel **62a** of the upper substrate cutting device **60.**

[00195] The cutter wheel **62a** of the upper substrate cutting device **60** is pressed so as to make contact onto the top surface of the bonded mother substrate **90** by the aforementioned energizing means and the moving means of the cutter head **62c.** The cutter wheel **62a** of the lower substrate cutting device **70** is pressed so as to make contact onto the bottom surface of the bonded mother substrate **90** by the aforementioned energizing means and the moving means of the cutter head **62c.** When the upper substrate cutting device **60** and the lower substrate cutting device **70** are simultaneously moved in the same direction, the bonded mother substrate **90** is cut.

[00196] It is preferred that the cutter wheel **62a** is rotatably supported by the cutter head **65** using the servo motor disclosed in WO 03/011777.

[00197] As shown in Figures **12** and **13**, the servo motor **65b** is supported in an inverted manner between a pair of side walls **65a**. A holder holding member **65c** is provided below the pair of side walls **65a** so as to be rotatable via a supporting axis **65d,** the holder holding member **65c** having an L shape when viewed from the side.

A tip holder **62b** is attached in front (on the right-hand side in Figure **13**) of the holder holding member **65c**. The tip holder **62b** is attached to rotatably support the cutter wheel **62a** via an axis **65e.** Flat bevel gears **65f** are mounted on the rotation axis of the servo motor **65b** and the supporting axis **65d** so as to engage with each other. Thus, the holder holding member **65c** performs a rotation operation in the up-and-down direction with the supporting axis **65d** as its supporting point and the cutter wheel **62a** moves upwards and downwards due to the forward and reverse rotation of the servo motor **65b**. The cutter heads **65** themselves are provided on the upper substrate cutting device **60** and the lower substrate cutting device **70**.

[00198] Figure **14** is a front view showing another example of cutter head using a servo motor. The rotation axis of the servo motor **65b** is directly connected to the holder member **65c**.

[00199] The cutter heads shown in Figures **12** and **14** move the cutter wheels **62a** upwards and downwards by rotating the servo motors using the position control so as to position the cutter wheel **62a**. The cutter heads transmit the scribing pressure for the brittle material substrate to the cutter wheel **62a** by controlling the rotation torque. The rotation torque acts to return the cutter wheel **62a** to the set position when the position of the cutter wheel **62a** is shifted from the positions previously set in the servo motors **65b** during the scribing operation for forming a scribing line on the bonded mother substrate **90** by moving the cutter heads in a horizontal direction. In other words, the servo motor **65b** controls the position in the perpendicular direction of the cutter wheel **62a,** and at the same time, the servo motor **65b** is an energizing means for the cutter wheel **62a**.

[00200] By using the cutter head **65** including the aforementioned servo motor, when the bonded mother substrate **90** is being scribed, the rotation torque of the servo

motor is corrected immediately in response to the change of the scribing pressure by the change in resistive force received by the cutter wheel **62a.** Thus, scribing is stably performed and a scribing line with excellent quality can be formed.

[00201] A cutter head is effectively applied to cutting the mother substrate in the substrate cutting system according to the present invention. The cutter head includes a mechanism for vibrating a scribing cutter (e.g., a diamond point cutter or a cutter wheel) which scribes the bonded mother substrate **90** so as to periodically change the pressure force of the scribing cutter on the bonded mother substrate **90.**

[00202] The structure of the upper substrate cutting device **60** and the lower substrate cutting device **70** is not limited to the aforementioned structure. In other words, any structure can be used, as long as the device has a structure for processing the top and bottom surfaces of the substrate so as to cut the substrate.

[00203] For example, the upper substrate cutting device **60** and the lower substrate cutting device **70** can be a device which cuts the mother substrate by using such as a laser light, a dicing saw, a cutting saw, or a diamond-studded blade cutter. When the mother substrate is made of a metal substrate (e.g., a steel plate), a wood plate, a plastic substrate or a brittle material substrate (e.g., a ceramic substrate, glass substrate or semiconductor substrate), a substrate cutting device for cutting the mother substrate by using, for example, a laser light, a dicing saw, a cutting saw, or a diamond-studded blade cutter is used.

[00204] Furthermore, when a bonded mother substrate for which a pair of mother substrate is bonded to each other, a bonded mother substrate for which different types of mother substrates are bonded to each other or a stacked substrate for which a plurality of mother substrates are stacked on each other is cut, a substrate

cutting device similar to the one used for cutting the aforementioned mother substrate can be used.

[00205] The upper substrate cutting device **60** and the lower substrate cutting device **70** may include a cutting assistance means for assisting the cutting of the substrate. As a cutting assistance means, for example, a means for pressing (e.g., a roller on the substrate), a means for spraying compressed air onto the substrate, a means for irradiating a laser onto the substrate or a means for warming (heating) the substrate by spraying such as heated air onto the substrate is used.

[00206] Furthermore, in the description above, the upper substrate cutting device **60** and the lower substrate cutting device **70** have the same structure. However, the upper substrate cutting device **60** and the lower substrate cutting device **70** can have structures different from each other, depending on the cutter pattern of the substrate or the cutting condition of the substrate.

[00207] The operation of the substrate cutting system, having such a structure will be described, mainly using a case in which a bonded substrate for which large-sized glass substrates are bonded to each other is cut.

[00208] When the bonded mother substrate **90** for which large-sized glass substrates are bonded to each other is cut into a plurality of panel substrates **90a** (see Figure **16**), first, as shown in Figure **15,** the bonded mother substrate **90** is carried in, by a transportation robot, etc., from the end of the substrate carry-in side to the substrate cutting system **1** according to the present invention. Thereafter, the bonded mother substrate **90** is mounted, in a horizontal state, on the timing belts **21e** of all the first substrate supporting units **21A** of the first substrate supporting section **20A.**

[00209] In this state, the bonded mother substrate **90** is pushed by pushers (not shown) so as to contact positioning pins (not shown) arranged along the frame **11B**

of the main frame **11,** and at the same time, the bonded mother substrate **90** is pushed by pushers (not shown) so as to contact positioning pins (not shown) arranged along the direction perpendicular to the frame **11B.** Thereby, the bonded mother substrate **90** is positioned at a predetermined position in the mounting base **10** in the substrate cutting system.

[00210] Thereafter, as shown in Figure **15**, the side edge of the bonded mother substrate **90,** which is positioned on the substrate carry-in side, is clamped by the clamp member **51** of each of the clamp devices **50** arranged in the substrate carry-in side so as to be perpendicular to the frame **11B**.

[00211] The clamp member **51** of each of the clamp devices **50** waits at a predetermined position where the rod **56** is shorted due to the cylinder **55** such that it does not block the carry-in of the bonded mother substrate **90** at the time of carry-in thereof. Then, after the bonded mother substrate **90** is positioned, the rod **56** is lengthened, and the clamp member **51** of each of the clamp devices **50** grips the side edge of the bonded mother substrate **90** on the substrate carry-in side.

[00212] When the side edge of the bonded mother substrate **90** on the substrate carry-in side is clamped by each of the clamp devices **50**, each clamp member **51**, which clamps the side edge of the bonded mother substrate **90,** lowers at approximately the same time due to the weight of the bonded mother substrate **90**. Therefore, the bonded mother substrate **90** is additionally supported by the timing belts **21e** of all the first substrate supporting units **21A.**

[00213] In this state, each clamp device **50** is slid to the substrate carry-in side such that the cutting device guide body **30** is located at a predetermined position above an adjacent side edge of the bonded mother substrate **90**, the bonded mother substrate **90** being clamped by each of the clamp devices **50** in a horizontal state. A

first optical device **38** and a second optical device **39** provided on the cutting device guide body **30**, move along the cutting device guide body **30** from respective waiting positions and capture a first alignment mark and a second alignment mark, respectively, provided on the bonded mother substrate **90**.

[00214] Simultaneous to when each clamp device **50** starts moving toward the substrate carry-out side, the timing belts **21e** of the first substrate supporting units **21A** of the first substrate supporting section **20A** and the timing belts **21e** of the second substrate supporting units **21B** of the second substrate supporting section **20B** are circled, by the driving of the motor, at the same speed as that of the bonded mother substrate **90** moving toward the carry-out side in the same direction, the bonded mother substrate **90** being clamped by each of the clamp devices **50**. The bonded mother substrate **90** clamped by the clamp devices **50** on the move is supported, without being rubbed against the respective timing belts **21e**, by the timing belts **21e** of the first substrate supporting units **21A** of the first substrate supporting section **20A** and the timing belts **21e** of the second substrate supporting units **21B** of the second substrate supporting section **20B.**

[00215] Next, based on the result of the captured first alignment mark and second alignment mark, the inclination of the bonded mother substrate **90** with respect to the cutting device guide body **30,** the starting position of cutting the bonded mother substrate **90** and the ending position of cutting the bonded mother substrate **90** are calculated by an operational processing device (not shown), the bonded mother substrate **90** being supported by each of the clamp devices **50** in a horizontal state. Based on the result of the calculation, each of the clamp devices **50** holding the bonded mother substrate **90** as well as the upper substrate cutting device **60** and the lower substrate cutting device **70** are moved so as to cut the bonded mother

substrate **90** (which is referred to as "scribing by linear interpolation" or "cutting" by linear interpolation).

[00216] In this case, as shown in Figure **16,** each cutter wheel **62a** facing each other is pressed so as to make contact onto the top surface and the bottom surface of the bonded mother substrate **90** and rolled on the top surface and the bottom surface of the bonded mother substrate **90**, respectively, so as to form scribing lines on the top surface and the bottom surface of the bonded mother substrate **90**.

[00217] The bonded mother substrate **90** is, for example, as shown in Figure **16,** cut so that two panel substrates **90a** are cut into two lines in a direction along the upper guide rail **31** and the lower guide rail **32**. The cutter wheel **62a** of the upper substrate cutting device **60** and the cutter wheel **62a** of the lower substrate cutting device **70** are pressed so as to make contact and rolled along the side edge of the panel substrates **90a** in order to cut four panel substrates **90a** from the bonded mother substrate **90.**

[00218] In this case, vertical cracks are created, by the cutter wheel **62a** of the upper substrate cutting device **60** and the cutter wheel **62a** of the lower substrate cutting device **70** on the part of the glass substrate where each cutter wheel **62a** is pressed so as to make contact and rolled. As a result, scribing lines **95** are formed thereon. Protrusions are formed, with a predetermined pitch, on the outer circumferential ridge of the blade edge of each cutter wheel **62a.** Thus, a vertical crack having about 90% of the thickness of the glass substrate in the thickness direction is formed on each glass substrate.

[00219] A cutter head is effectively applied to cutting the mother substrate in the substrate cutting system according to the present invention, the cutter head including a mechanism for vibrating a scribing cutter (e.g., a diamond point cutter or

a cutter wheel) which scribes the bonded mother substrate **90** so as to periodically change (vibrate) the pressure force of the scribing cutter on the bonded mother substrate **90**.

[00220] Regarding the method for scribing the front and back surfaces of the bonded mother substrate **90**, a conventional method as shown in Figure **17**, in which scribing lines are formed in turn along lines to be scribed S1 to S4 along a vertical direction, which is a narrow side direction of the bonded mother substrate **90**, and then scribing lines are formed in turn along lines to be scribed S5 to S8 along the horizontal direction, which is wide side direction, can be used in general.

[00221] Besides the above-described scribing method, a scribing method as shown in Figure **18** can be preferably used for the substrate cutting system of the present invention. In Figure **18**, four panel substrates **90a** are formed from one bonded mother substrate **90**.

[00222] The bonded mother substrate **90** has a rectangular shape. Four panel substrates **90a** are obtained by forming two panel substrates **90a** along the longitudinal direction of the bonded mother substrate **90** and forming two panel substrates **90a** along the width direction which is orthogonal to the longitudinal direction. Each of the panel substrates **90a** is formed with an appropriate space apart from the adjacent panel substrate **90a** and from side edges along the longitudinal direction and side edges of the width direction of the bonded mother substrate **90**.

[00223] By having the cutter wheel **62a** of the upper substrate cutting device **60** and the cutter wheel **62a** of the lower substrate cutting device **70** oppose each other and being pressed and rolled at the same time, scribing lines across the entire

circumference are formed on the front and back surface of the bonded mother substrate **90** for each of the panel substrates **90a** one by one in turn.

[00224] In this case, first, scribing line is formed along one linear line to be scribed S1 along the side edges parallel to the longitudinal direction of the bonded mother substrate **90** for the panel substrate **90a** to be scribed. More specifically, the cutter wheels **62a** of the cutter heads **62c** are pressed and rolled on the bonded mother substrate **90** along the line to be scribed S1.

[00225] In Figure **19**, it is shown that the scribing start point by the cutter wheels **62a** is a position on the bonded mother substrate **90** (a position for internal cut). However, it may be a position near the outside of the end surface of the bonded mother substrate **90** along the line to be scribed S1 (a position for external cut).

[00226] When the scribing line is formed along the line to be scribed S1 by a vertical crack which extends across the entirety of the thickness direction, each of the clamp devices **50** holding the bonded mother substrate **90** is moved in the Y direction and the upper substrate cutting device **60** and the lower substrate cutting device **70** are moved in the X direction at the same time such that the cutter wheels **62a** revolves around the vertical axis by 270 degrees to form a circular trace having a radius of about 1 mm (a corner portion A in Figure **19**).

[00227] When the cutter wheels **62a** are revolving, the pressure of the cutter wheels **62a** to the bonded mother substrate **90** is reduced so that there is no deep vertical crack formed on the bonded mother substrate **90**. When the thickness of the bonded substrate **90** is 0.7 mm, the depth of the vertical crack formed in the bonded mother substrate **90** when the cutter wheels **62a** is revolving is about 100 μm to 200 μm.

[00228] When the cross-scribing is performed by the cutter wheels **62a** as shown in Figure **17**, a chip tends to be generated in the bonded mother substrate **90** at cross

points of the scribing lines formed when scribing to performed in a first direction and scribing is performed in a second direction.

[00229] Since a vertical crack which almost extends to the thickness of the bonded mother substrate **90** has been already formed when scribing is performed in the first direction, the mother glass substrate **90** sinks in front of the first scribing line when the cutter wheels **62a** reach near the scribing line in the first direction while scribing in the second direction and such a chip may be generated when the cutter wheels **62a** run on the glass substrates along the scribing line in the first direction at a crossing portion of the scribing line in the first direction and a scribing line in the second direction.

[00230] In the scribing method as shown in Figure **18**, the cutter wheels **62a** revolve and cross the scribing line which has been already formed along the line to be scribed S1 with the pressure to the bonded mother substrate **90** being reduced. Thus, a part of the bonded mother substrate **90** does not sink before the scribing lines cross each other, and thus, it is possible to prevent a chip from occurring in the bonded mother substrate **90** when the scribing lines cross each other.

[00231] When travel direction of the cutter wheels **62a** revolve by 270 degrees and the cutter wheels **62a** are along the linear line to be scribed S2 along the width direction of the panel substrates **90a** which are orthogonal to the line to be scribed S1, the cutter wheels **62a** are pressed and rolled along the line to be scribed S2. Thus, the scribing line is formed by a vertical crack which extends across the entirety of the thickness direction along the line to be scribed S2.

[00232] Then, in a similar manner, the cutter wheels **62a** revolve by 270 degrees to a direction orthogonal to the line to be scribed S2 while forming a circular trace having a radius of about 1 mm in corner portion B without separating the cutter wheels **62a**

from the front and back surfaces of the bonded mother substrate **90**. Thus, the cutter wheels **62a** are along the line to be scribed S3 and form the scribing line by a vertical crack which extends across the entirety of the thickness direction along the line to be scribed S3. Furthermore, again, the cutter wheels **62a** revolve by 270 degrees to a direction orthogonal to the line to be scribed S3 while forming a circular trace having a radius of about 1 mm in corner portion C without separating the cutter wheels **62a** from the front and back surfaces of the bonded mother substrate **90**. Thus, the cutter wheels **62a** are along the line to be scribed S4 and form the scribing line on the top and bottom surfaces of the bonded mother substrate **90** by a vertical crack which extends across the entirety of the thickness direction along the line to be scribed S4.

[00233] In this way, a closed curve including four linear scribing lines is formed around a panel substrate **90a**. Then, for example, in order to form the panel substrate **90a** adjacent in the longitudinal direction of the bonded mother substrate **90**, a closed area with four linear scribing lines is similarly formed around the panel substrate **90a**. Then, closed areas with four linear scribing lines are formed across the entire circumference for each of the remaining pair of the panel substrates **90a** in turn.

[00234] Furthermore, besides the above-described scribing method, a scribing method as shown in Figure **19** can be preferably used in the substrate cutting system of the present invention. In Figure **19**, four panel substrates **90a** are formed from one bonded mother substrate **90**.

[00235] In the scribing method shown in Figure **19**, scribing lines along lines to be scribed S1 and S2 which are orthogonal to each other on the panel substrates **90a** are formed in the method as described above. For forming the scribing line along

the line to be scribed S1, the cutter wheels **62a** is positioned in the vicinity of outside the end surface of the bonded mother substrate **90** and the scribing line along the line to be scribed S1 is continuously formed therefrom.

[00236] A chip which may be generated when the cutter wheels **62a** run on the front and back surfaces of the bonded mother substrate **90** at the start of scribing does not affect the panel substrates **90a** to become products.

[00237] Then, the cutter wheels **62a** revolve by 270 degrees to a direction orthogonal to the line to be scribed S1 while forming a circular trace in the corner portion A. Thus, the cutter wheels **62a** are along the line to be scribed S2 and form the scribing line by a vertical crack which extends across most of the entirety of the thickness direction along the line to be scribed S2.

[00238] Then, the cutter wheels **62a** are temporarily separated from the surface of the bonded mother substrate **90**, and the scribing lines along the lines to be scribed S3 and S4 in a direction orthogonal to the line to be scribed S1 are formed in this order. In this case, a chip, which may be generated when the cutter wheels **62a** run on the front and back surfaces of the bonded mother substrate **90** at the start of scribing, does not affect the panel substrates **90a** to become products.

[00239] In this way, four linear scribing lines are formed around the panel substrate **90a**. Then, for example, for forming the panel substrate **90a** adjacent in the longitudinal direction of the bonded mother substrate **90**, four linear scribing lines are similarly formed across the entire circumference of the panel substrate **90a**. Then, closed areas with four linear scribing lines are formed across the entire circumferences for each of the remaining pair of the panel substrates **90a** in turn.

[00240] After the scribing lines are formed on the bonded mother substrate by the above-described scribing method, as shown in Figure **20**, with the bonded mother

substrate **90** on which the scribing line **95** is formed being supported by the timing belts **21e** of the second substrate supporting units **21B**, the steam unit section **160** moves toward the substrate carry-in side and blows the steam entirely on the front and back surfaces of the bonded mother substrate **90** on which the scribing lines are carved to completely cut the bonded mother substrate **90**. At the same time, the water remaining on the front and back surfaces of the bonded mother substrate **90** after the steam is blown thereto is removed by the air knife **165**.

[00241] By blowing the steam onto the entire front and back surface of the bonded mother substrate **90** having the scribing lines carved thereon, the scribing lines formed by the cutter wheels **62a** experience volume expansion since the front and back surface portions of the bonded mother substrate **90** are heated. In this way, vertical cracks extend from the surface of the upper and lower mother substrates of the bonded mother substrate **90** toward the bonded surface, and the bonded mother substrate **90** is completely cut.

[00242] Thereafter, as shown in Figure **20**, all the panel substrates **90a** cut from the bonded mother substrate **90** on the timing belts **21e** of all the second substrate supporting units **21B** of the second substrate supporting section **20B** are carried out by the carrying robot **140** of the substrate carry-out device **80**, and thus, a cut bonded mother substrate **90'** (portion to be discarded) is supported by the timing belts **21e** of the second substrate supporting units **21B**.

[00243] Then, the substrate carry-out device **80** and the steam unit section **160** moves toward the end portion on the substrate carry-out side.

[00244] After the substrate carry-out device **80** and the steam unit section **160** are moved to the end of the substrate carry-out side, the clamp member **51** of each of the clamp devices **50** is open, and the state of the cut bonded mother substrate **90'**

is changed from being gripped by the clamp members **51** to being only supported by the timing belt **21e** of each of the second substrate supporting units **21B.**

[00245] When the cut bonded mother substrate **90'** is supported by the timing belt **21e** of each of the second substrate supporting units **21B**, as shown in Figure **21,** each of the clamp devices **50** is caused to move toward the substrate carry-in side and the timing belts **21e** of all the second substrate supporting units **21B** of the second substrate supporting section **20B** are circled. Therefore, the cut bonded mother substrate **90'** (portion to be discarded or cullet) falls down. In this case, the cut bonded mother substrate **90** (portion to be discarded) which has fallen is guided by a guide plate arranged in a slanted state so as to be accommodated into a cullet accommodation box.

[00246] By employing the scribing method which will be described below as the scribing method by the upper substrate cutting device **60** and the lower substrate cutting device **70** of the cutting device guide body **30**, a cutting process of the bonded substrate by the steam unit section **160** can be omitted.

[00247] In this case, as shown in Figure **22**, the cutter wheels **62a** are pressed and rolled on an upper mother substrate **91** and a lower mother substrate **92** of the bonded mother substrate **90** along lines to be cut on the mother substrates **91** and **92** for scribing the mother substrates **91** and **92**. Thus, vertical cracks Vm along thickness directions of the mother substrates **91** and **92** are sequentially formed along the lines to be cut, and main scribing lines MS are formed. The vertical cracks Vm are formed such that they extend by 80% or more of the thickness of the mother substrates **91** and **92**, and more preferably, 90% or more from surfaces of the mother substrates **91** and **92**.

[00248] Thereafter, in the area outside the panel substrates obtained by cutting the mother substrates **91** and **92**, the mother substrates **91** and **92** are scribed by pressing and rotating the cutter wheels **62a** along the main scribing lines MS on the mother substrates **91** and **92** with spaces of about 0.5 to 1.0 mm apart from the main scribing lines MS. In this way, vertical cracks Vs along the thickness directions of the mother substrates **91** and **92** are sequentially formed along the main scribing lines MS to form supplementary scribing lines SS.

[00249] At this time, the cutter wheels **62a** press and roll on the surfaces of the mother substrates **91** and **92**, and the blades thereof cut into the surfaces of the mother substrates **91** and **92**. Thus, a compressed force is applied to the surfaces of the mother substrates **91** and **92** and the compressed force has influence on the surface portions of the vertical cracks Vm in the main scribing lines MS which have been already formed. In this example, the vertical cracks Vm forming the main scribing lines MS are formed to extend by 80% or more of the thickness of the mother substrates **91** and **92**. Thus, when the surface portion of the mother substrates **91** and **92** are compressed, the vertical cracks Vm of the main scribing lines MS have gaps on the surface portions of the mother substrates **91** and **92** are compressed and gaps on bottom portions are widened. Therefore, the vertical cracks Vm are elongated toward the bonded surface of the mother substrates **91** and **92**. When the vertical cracks Vm reach the bonded surface of the mother substrates **91** and **92** and the vertical cracks Vm reach the bonded surface of the mother substrates **91** and **92** across the entirety of the main scribing lines MS, the bonded mother substrate **90** is cut along the main scribing lines MS.

[00250] It is preferable that the supplementary scribing lines SS are formed with spaces of about 0.5 to 1.0 mm apart from the main scribing lines MS. When the

spaces between the supplementary scribing lines SS and the main scribing lines MS are smaller than 0.5 mm, a large compression force is applied to the surface portion of the vertical cracks Vm forming the main scribing lines MS, and damage such as chips may occur in the surface side end portions of the vertical cracks Vm. On the other hand, when the space to larger than 1.0 mm, the compression force applied to the vertical cracks Vm on the main scribing lines MS is not enough, and the vertical cracks Vm may not reach the bonded surface of the mother substrates **91** and **92**.

[00251] As described above, by forming double scribing lines of the main scribing lines MS and the supplementary scribing lines SS with predetermined spaces, a plurality of panel substrates **90a** are cut out of the bonded mother substrate **90**.

[00252] Figure **23** is a diagram for illustrating a scribing pattern for cutting panel substrates **90a** out of the bonded mother substrate **90** by using such double scribing lines of the main scribing lines MS and the supplementary scribing lines SS. The cutter wheels **62a** of the upper substrate cutting device **60** and the lower substrate cutting device **70** run along side edges of the substrate carry-out side of two panel substrates **90a** on the substrate carry-out side of the bonded mother substrate **90**, and a double scribing line (main scribing line MS1 and supplementary scribing line SS1) is formed on the side edges of the substrate carry-out side of the two panel substrates **90a**.

[00253] Thereafter, main scribing line MS2 and supplementary scribing line SS2 are formed along the side edges of the substrate carry-in side of the two panel substrates **90a** on the substrate carry-out side of the bonded mother substrate **90**. When the side edges of the substrate carry-out side and the substrate carry-in side of the two panel substrates **90a** on the substrate carry-out side of the bonded mother substrate **90** are cut, the clamp devices **50** holding the bonded mother

substrate **90** is slid toward the substrate carry-out side so that the cutter wheels **62a** locate on the side edge portion located on the substrate carry-out side of the bonded mother substrate **90**. Then, the upper substrate cutting device **60** and the lower substrate cutting device **70** slide along the upper guide rail **31** and the lower guide rail **32** so that the cutter wheels **62a** of the upper substrate cutting device **60** and the lower substrate cutting device **70** are on an extension of the side edge of the panel substrate **90a** on the substrate carry-out side and close to the frame **11A** of the main frame **11**, which is close to the main frame **11**. Along the extension of the side edge, a double scribing line (main scribing line MS3 and supplementary scribing line SS3) is formed, and the side edge close to the frame **11A** of the panel substrate **90a** on the substrate carry-out side and close to the frame **11A** of the main frame **11** is cut.

[00254] Thereafter, double scribing lines (main scribing lines MS4 to MS6 and supplementary scribing lines SS4 to SS6) are formed in parallel with the frame **11A** in a similar manner. Thus, side edges of the panel substrates **90a** located on the substrate carry-out side in a direction along the frame 11A are respectively cut.

[00255] Thereafter, regarding two other panel substrates **90a** along the upper guide rail **31** and the lower guide rail **32**, side edges of the panel substrates **90a** are cut by forming double scribing lines (main scribing lines MS7 to MS12 and supplementary scribing lines SS7 to SS12) along side edges of the panel substrates **90a**.

[00256] In the above description, an example where double scribing lines are individually formed has been explained. However, the present invention is not limited to such a method. As long as the double scribing lines are formed along the side edges of the panel substrates **90a**, any method can be used. For example,

double scribing lines can be formed on the side edges of the panel substrates **90a** by using one scribing line.

[00257] Figure **24** is a plan view for illustrating a scribing pattern for cutting panel substrates **90a** out of the bonded mother substrate **90** by using double scribing lines of the main scribing lines MS and the supplementary scribing lines SS. In this example, the mother substrates **91** and **92** of the bonded mother substrate **90** are cut along first to eighth lines to be cut D1 through D8 in this order to become four panel substrates **90a** arranged in two rows and two columns.

[00258] The first line to be cut D1 corresponds to side edges of two panel substrates **90a** in a first row along a row direction (horizontal direction in the figure), and is spaced apart from a side edge of the bonded mother substrate **90** along the row direction by a predetermined space. The second line to be cut D2 corresponds to side edges of the two panel substrates **90a** in the first row, which are close to the panel substrate **90a** in a second row. The third line to be cut D3 corresponds to side edges of two panel substrates **90a** in the second row which are close to the panel substrates **90a** in the first row, and is spaced apart from the second line to be cut D2 by 2 to 4 mm. The fourth line to be cut D4 corresponds to side edges of the two panel substrates 90a in the second row in a row direction (horizontal direction in the figure), and is spaced apart from the other side edges of the bonded mother substrate **90** along the row direction by a predetermined space.

[00259] The fifth line to be cut D5 corresponds to side edges of two panel substrates **90a** in a first column along the column direction (vertical direction in the figure), and is spaced apart from one side edge of the bonded mother substrate **90** along the column direction. The sixth line to be cut D6 corresponds to the side edges of the two panel substrates **90a** in the first column, which are close to panel substrates

90a in a second column. The seventh line to be cut D7 corresponds to side edges of the two panel substrates **90a** in the second column, which are close to the panel substrates **90a** in the first column, and is spaced apart from the sixth line to be cut D6 by 2 to 4 mm. The eighth line to be cut D8 corresponds to the side edges of the two panel substrates **90a** in the second column along the column direction (vertical direction in the figure), and is spaced apart from the other side edges of the bonded mother substrate **90** along the column direction by a predetermined space.

[00260] In cutting such a bonded mother substrate **90**, first, the cutter wheels **62a** are pressed and rolled along, for example, the first to fourth lines to be cut D1 to D4 in this order. Thus, first to fourth main scribing lines MS13 to MS16 are formed by vertical cracks having depths of 90% or more of the thicknesses of the mother substrates **91** and **92** from the surface of the upper and lower mother substrates **91** and **92** of the bonded mother substrate **90**.

[00261] In this state, the cutter wheels **62a** are pressed and rolled along the fifth line to be cut D5. Thus, fifth main scribing line MS17 is formed along the fifth line to be cut D5.

[00262] Thereafter, sixth to eighth main scribing lines MS18 to MS20 are formed along the sixth through eighth lines to be cut D6 to D8 in this order by pressing and rotating the cutter wheels **62a** along the sixth through eighth lines to be cut D6 to D8 in turn in a similar manner.

[00263] In this manner, after the first through eighth main scribing lines MS 13 to MS 20 are formed as such, first supplementary scribing line SS13 to formed along the first main scribing line MS13 by pressing and rotating the cutter wheels **62a** in a side edge portion of the bonded mother substrate **90**, which is on the opposite side of the panel substrates **90a** with respect to the first main scribing line MS13, with a space

of about 0.5 to 1.0 mm from the first main scribing line MS13. Thus, vertical cracks on the first main scribing line MS13 extend toward the bonded surface of the mother substrates **91** and **92** of the bonded mother substrate **90** and reach the bonded surface of the mother substrates **91** and **92**. Such a phenomenon occurs across entirety of the first main scribing line MS13, and the bonded mother substrate **90** is cut along the first main scribing line MS13.

[00264] Next, a second supplementary scribing line SS14 is formed along the second main scribing line MS14 by the cutter wheels **62a** in an area opposite to the panel substrates **90a** with respect to the second main scribing line MS14, with a space of about 0.5 to 1.0 mm from the second main scribing line MS14. Thus, vertical cracks on the second main scribing line MS14 extend toward the bonded surface of the mother substrates **91** and **92** of the bonded mother substrate **90** from the surfaces of the mother substrates **91** and **92** of the bonded mother substrate **90**, and the vertical cracks reach the bonded surface of the mother substrates **91** and **92** across the entirety of the second main scribing line MS14. In this way, the bonded mother substrate **90** is cut along the second main scribing line MS14.

[00265] Along the third main scribing line MS15 and the fourth main scribing line MS16, third supplementary scribing line SS15 and a fourth supplementary scribing line SS16 are respectively formed on the side opposite to the panel substrates **90a**. Thus, the bonded mother substrate **90** is sequentially cut along the third main scribing line MS15 and the fourth main scribing line MS16.

[00266] Thereafter, along the fifth to eighth main scribing lines MS17 to MS20, fifth to eighth supplementary scribing lines SS17 to SS20 are formed on the side opposite to the panel substrates **90a** respectively between the first main scribing line MS13 and the second main scribing line MS14, and between the third main scribing line

MS15 and the fourth main scribing line MS16. Thus, the bonded mother substrate **90** are cut along the fifth to eighth main scribing lines MS17 to MS20 and unnecessary portions are removed. As a result, four panel displays **90a** can be obtained.

[00267] In this case, the first to eighth main scribing lines MS13 to MS20 are formed between end surfaces of the bonded mother substrate **90**, more specifically, formed across the entirety of the lines to be cut D1 to D8 formed across one end surface of the bonded mother substrate **90** to the opposing other end surface. Further, the first to eighth supplementary scribing lines SS13 to SS20 are respectively formed across the end surface or one cut surface which has been cut to the opposing other end surface or the other cut surface.

[00268] The present invention is not limited to the method in which the first to eighth main scribing lines MS13 to MS20 are formed across the entirety of the lines to be cut D1 to D8 formed between the end surfaces of the bonded mother substrate **90**, the first to fourth supplementary scribing lines SS13 to SS16 across the one end surface of the bonded mother substrate **90** and the opposing other end surface, and the fifth to the eighth supplementary scribing lines SS17 to the SS20 are formed across one cut surface of the bonded mother substrate **90** to the opposing other cut surface. As shown in Figure **25**, positions spaced apart from the one end surface of the mother glass substrate **90** by about 0.2 to 0.5 mm may be the start positions of the first to eighth main scribing lines MS13 to MS 20, and similarly, positions in front of is the other end surfaces by about 0.2 to 0.5 mm may be end portions of the first to eighth main scribing lines MS13 to MS20.

[00269] In this case, when the cutter wheels **62a** are pressed and rolled on the mother substrates **91** and **92** of the bonded mother substrate **90** to perform scribing

for forming the first to eighth main scribing lines MS13 to MS20, vertical cracks extend in back and front directions of the scribing direction with respect to the scribing start positions. Thus, the first to eighth main scribing lines MS13 to MS20 to be formed reach one end surface of the mother substrates **91** and **92** of the bonded mother substrate **90**.

[00270] Similarly, even though the scribing end positions of the first to eighth main scribing lines MS13 to MS20 are in front of the other end surface of the mother substrates **91** and **92** of the bonded mother substrate **90**, since the vertical cracks in the mother substrates 91 and 92 extend in the scribing direction, the first to eighth main scribing lines MS13 to MS20 to be formed reach the other end surface of the mother substrates **91** and **92**.

[00271] This shows that it is not necessary to form first to eighth supplementary scribing lines SS13 to SS20 across one end surface or one cut surface which has been cut of the mother substrates **90** and **91** to the opposing other end surface or the opposing other cut surface. As shown in Figure **25**, positions appropriately spaced apart from one end surface or the one cut surface which has been cut of the mother substrates **91** and **92** of the bonded mother substrate **90** by 0.2 to 0.5 mm may be start positions of the first to eighth supplementary scribing lines SS13 to SS20. Similarly, positions in front of the other end surface or cut surface by about 0.2 to 0.5 mm may be end positions of the first to eighth supplementary scribing lines SS13 to SS20.

[00272] Furthermore, one of the first to eighth main scribing lines MS13 to MS20 and the first to eighth supplementary scribing lines SS13 to SS20 may be formed across the one end surface or one cut surface which has been cut of the mother substrates **91** and **92** of the bonded mother substrate to the other end surface or the other cut

surface of the mother substrates **91** and **92**, and the other of the first to eighth main scribing lines MS13 to MS20 and the first to eighth supplementary scribing lines SS13 to SS20 may be formed across the position appropriately space apart from the one end surface or one cut surface which has been cut of the mother substrates **91** and **92** of the bonded mother substrate **90** to positions in front of the other end surface or the other cut surface of the mother substrates **91** and **92**.

[00273] Figure **26** is a plan view for illustrating another scribing pattern for cutting the panel substrates **90a** out of the bonded mother substrate **90**. In this scribing method, first and second main scribing lines MS13 and MS14 are formed by the cutter wheels **62a**, along first and second lines to be cut D1 and D2 on the bonded mother substrate **90** along the horizontal direction are respectively formed by vertical cracks which extend to 90% or more of the thicknesses of the mother substrates **91** and **92** from the surfaces of the mother substrates **91** and **92** of the bonded mother substrate **90**. Thereafter, in the area between the first and second main scribing lines MS13 and MS14, fifth main scribing line MS17 along the fifth line to be cut D5 along the vertical direction is formed by the cutter wheels **62a**, and fifth supplementary scribing lines SS17 is formed on the side opposite to the panel substrates **90a** being spaced apart from the fifth main scribing line MS17 by about 0.5 to 1.0 mm.

[00274] In this case, the fifth main scribing line MS17 and the fifth supplementary scribing line SS17 respectively cross the first and second main scribing lines MS13 and MS14. The fifth main scribing line MS17 runs over the second main scribing line MS14 and then is inverted by 180 degrees to form the fifth supplementary scribing line SS17 so that the fifth main scribing line MS17 and the fifth supplementary scribing line SS17 are formed continuously with one scribing.

[00275] Thereafter, similarly, in the area between the first and second main scribing lines MS13 and MS14, sixth scribing line MS18 is formed by the cutter wheels **62a** along sixth line to be cut D8, and then is inverted to form sixth supplementary scribing line SS18 on the side opposite to the panel substrates **90a** in a continuous manner. Further, seventh main scribing line MS19 and seventh supplementary scribing lines SS19, and eight main scribing line MS20 and eighth supplementary scribing lines SS20 are formed similarly in turn. Since the fifth to eighth main scribing lines MS17 to MS20 and the fifth to eighth supplementary scribing lines SS17 to SS20 pass across the first and second main scribing lines MS13 and MS14, it is ensured that vertical cracks forming the first and second main scribing lines MS13 and MS14 reach the bonded surface of the mother substrates **91** and **92** of the bonded mother substrate **90** across the entirety of the first and second main scribing lines MS13 and MS14, and a pair of the panel substrates **90a** are obtained.

[00276] Before the substrate is cut into the pair of the panel substrates **90a** at this point, an area of the bonded mother substrate **90** which has not been cut is referred to a second substrate portion **90c**.

[00277] Next, as shown in Figure **26(b)**, on the second substrate portion **90**c cut by the second main scribing line MS14, the cutter wheels 62a are pressed and rolled along the third and fourth lines to be cut D3 and D4 on the bonded mother substrate **90** along the vertical direction, and third and fourth main scribing lines MS15 and MS16 are formed by vertical cracks extended to 90% or more of the thicknesses of the mother substrates **91** and **92** from the surfaces of the mother substrates **91** and **92** of the bonded mother substrate **90**. Thereafter, in the area between the third and fourth main scribing lines MS15 and MS16, ninth main scribing line MS21 and fifth supplementary scribing line SS21 along ninth line to be cut D9 along the vertical

direction, tenth main scribing line MS22 and tenth supplementary scribing line SS22 along the tenth line to be cut D10, eleventh main scribing line MS23 and eleventh supplementary scribing line SS23 along the eleventh line to be cut D11, and twelfth main scribing line MS24 and twelfth supplementary scribing line SS24 along the twelfth line to be cut D12 are sequentially formed outside the panel substrates **90a** so as to cross the third and fourth main scribing lines MS15 and MS16. Thus, the second substrate portion **90c** is cut, and a pair of panel substrates **90a** is cut.

[00278] It is not necessary that the fifth to twelfth supplementary scribing lines SS21 to SS24 cross the first and third main scribing lines MS13 and MS15. For example, as shown in Figure **27**, positions in front of the first and third main scribing lines MS13 and MS15 by about 0.2 to 0.5 mm may be end portions of the fifth to twelfth supplementary scribing lines SS17 to SS24. In such a case, vertical cracks forming the fifth to twelfth supplementary scribing lines SSI7 to SS24 also extend in the scribing direction. The fifth to twelfth main scribing lines MS17 to MS24 are cut across the entirety of the main scribing lines MS17 to MS24.

[00279] In the case where the scribing lines are formed to cross each other for cutting the substrate as described above, as shown in Figure **28**, first, the main scribing lines MS13 to MS16 are formed on the mother substrate **90** along the first to fourth lines to be cut D1 to D4, and then, the fifth main scribing line MS17 and the fifth supplementary scribing line SS17, the sixth main scribing line MS18 and the sixth supplementary scribing line SS18, the seventh main scribing line MS19 and the seventh supplementary scribing line SS19, and the eighth main scribing line MS20 and the eighth supplementary scribing line SS20 are formed to respectively cross the first main scribing line MS13 and fourth main scribing line MS16 such that the main scribing lines and the supplementary scribing lines are formed continuously

with one scribing by inverting the line by 180 degrees after they cross over the fourth main scribing line MS16.

[00280] Figure **29** is a schematic plan view for illustrating a scribing pattern for cutting the display panels **90a** out of the bonded mother substrate **90** by using double scribing lines of main scribing lines MS and supplementary scribing lines SS. First, with the scribing method shown in Figure **18**, four scribing lines along lines to be scribed S1 to S4 with respect to the panel substrates **90a** (hereinafter, four linear scribing lines across the entire circumferences of the panel substrates **90a** will be referred to as main scribing line DS1) are formed. Then, outside the panel substrates **90a** with respect to the main scribing line DS1, four linear sub-scribing line DS2 in parallel to the main scribing line DS1 spaced apart from the main scribing line DS1 by about 0.5 to 1 mm.

[00281] As described above, when the sub-scribing line DS2 is formed with a space of about 0.5 to 1 mm apart from the main scribing line DS1, a stress applied to a horizontal direction which is orthogonal to the formation direction of the scribing lines on a surface of the bonded mother substrate **90** when the sub-scribing line DS2 is formed. Thus, a compression force is applied to surface portions of the vertical cracks which form the main scribing line DS1 which has been already formed. When the compression force is applied to the surface portion of the vertical cracks forming the main scribing line DS1 as such, a reaction force is applied in a direction to widen the width of the vertical cracks forming the main scribing line DS1. In this way, the vertical cracks extend in the thickness direction of the bonded mother substrate **90** and the vertical cracks reach the bonded surface of the mother substrates **91** and **92** of the bonded mother substrate.

[00282] In this case, as shown in Figure **30**, sub-scribing line DS2 may be formed continuously after the main scribing line DS1 without separating the cutter wheels **62a** from the front and back surfaces of the bonded mother substrate **90** after the main scribing line DS1 is formed.

[00283] Furthermore, as shown in Figure **19**, when scribing lines are first formed along lines to be scribed S1 and S2, and then scribing lines are continuously formed along lines to be scribed S4 and S2, as shown in Figure **31**, the sub-scribing line DS2 may be formed after the main scribing line DS1 is formed.

[00284] Further, as a method for cutting the substrate, a method in which double scribing lines are formed on the bonded mother substrates where the glass substrates, which is a type of brittle material substrate, are bonded as mother substrates has been described. However, the present invention is not limited to this. When the substrate is a metal substrate such as steel sheet, wood plate, a plastic substrate, and a brittle material substrate such as ceramics substrate, glass substrate, semiconductor substrate or the like, a method for cutting the substrate by using, for example, laser light, a dicing saw, a diamond-studded blade cutter, or the like can be used.

[00285] Furthermore, the substrates include, besides mother substrate, a bonded substrate formed by bonding the same type of mother substrates, a bonded mother substrate for which different types of mother substrates are bonded, and a substrate for which a pair of mother substrates is stacked on each other.

EMBODIMENT 2

[00286] Figure **32** is a schematic perspective view showing an example of another embodiment of the entire substrate cutting system according to the present invention. Figure **33** is a plan view of the substrate cutting system. Figure **34** is a

side view of the substrate cutting system. In the present invention, the term "substrate" includes a single plate, such as a mother substrate cut into a plurality of substrates, a metal substrate (e.g., a steel plate), a wood plate, a plastic plate and a brittle material substrate (e.g., a ceramic substrate, a semiconductor substrate and a glass substrate). However, the substrate according to the present invention is not limited to such a single plate. Furthermore, the substrate according to the present invention includes a bonded substrate for which a pair of substrates is bonded to each other and a stacked substrate for which a pair of substrates is stacked on each other.

[00287] In the substrate cutting system in the present invention, for example, when a panel substrate (bonded substrate for display panel) for a liquid crystal device is manufactured from a pair of glass substrates bonded to each other, a plurality of panel substrates (bonded substrate for display panel) are cut, by the substrate cutting system according to the present invention, from the bonded mother substrate **90** for which a pair of mother glass substrates is bonded to each other.

[00288] The substrate cutting system **200** according to Embodiment 2 includes a positioning unit section **220**, a scribing unit section **240**, a buffer conveyor section **260**, a steam break unit section **280**, a substrate transportation unit section **300**, a panel inversion unit section **320** and a panel terminal separation section **340**.

[00289] In a substrate cutting system **200** according to Embodiment 2 of the present invention, description will be made by referring to the side where a positioning unit section **220** is arranged as a "substrate carry-in side" and to the side where a panel terminal separation section **340** is arranged as a "substrate carry-out side", respectively. In the substrate cutting system **200** according to the present invention, the direction in which a substrate is transported (flow direction of the substrate) is

+Y direction from the substrate carry-in side to the substrate carry-out side. The direction in which the substrate is transported is a direction perpendicular to a cutting device guide body **242** of the scribing unit section **240** in a horizontal state. The cutting device guide body **242** is provided along the X direction.

[00290] A case in which a bonded mother substrate **90** used as a substrate is cut will be described as an example. The bonded mother substrate **90** is carried in the positioning unit section **220** by a transportation device (not shown), which is used for the previous step. Thereafter, the positioning unit section **220** positions the bonded mother substrate **90** on belts **221e** provided on a plurality of substrate supporting units **221.**

[00291] As shown in Figure **35**, the positioning unit section **220** includes a guide bar **226** and a guide bar **227** above a mounting base **230**. The guide bar **226** extends along one side edge of the mounting base **230** along a Y direction via a pillar **228.** The guide bar **227** extends along one side edge of the mounting base **230** in parallel to the guide bar **226.** The positioning unit section **220** includes a guide bar **225** above the mounting base **230** between the guide bar **226** and the guide bar **227** on the substrate carry-in side of the mounting base **230**. The guide bar **225** extends along an X direction via the pillar **228.**

[00292] A plurality of reference rollers **223** are provided on the guide bar **225** and the guide bar **226**, respectively, the plurality of reference rollers **223** are used as a reference when the bonded mother substrate **90** is positioned. The guide bar **227** includes a plurality of pushers **224**. The plurality of pushers **224** push the bonded mother substrate **90** toward the reference rollers **223** provided on the guide bar **226** when the bonded mother substrate **90** is positioned.

[00293] Above the mounting base **230,** a plurality of substrate supporting bases **221** is provided, along the Y direction, between the guide bar **226** and the guide bar **227** with a predetermined interval. The substrate supporting bases **221** are held by an up-and-down moving device **222** provided on the top surface of the guide bar **226** side of the mounting base **230** and an up-and-down moving device **222** provided on the top surface of the guide bar **227** side of the mounting base **230**.

[00294] Each of the substrate supporting units **221** includes a belt **221e** which circles along the Y direction, a driving pulley **221b** and a coupled driving pulley **221c**. The driving pulleys **221b** each are connected to a driving axis **231.** The driving axis **231** is connected to the rotation axis of a motor **233** via a coupling (not shown). The motor **233** is driven due to an instruction from a control section (not shown) for controlling the substrate cutting system **200** according to the present invention. The driving axis **231** rotates at a predetermined speed clockwise and anticlockwise. The rotating speed of the driving axis **231** varies depending on the instruction from the control section. When the driving axis **231** rotates at the predetermined speed, the driving pulley **221b** of each of the substrate supporting bases **221** rotates. Thus, the belt **221e** circles along the Y direction. The coupled driving pulleys **221c** each are rotatably held to a coupled driving axis **232** and rotated in accordance with the circling of the belts **221e.**

[00295] The bonded mother substrate **90** positioned by the positioning unit section **220** is transported to a predetermined position of the first substrate supporting section **241A** of the scribing unit section **240** when the belt **221e** of each of the substrate supporting units **221** of the positioning unit section **220** and the timing belt of each of the plurality of the first substrate supporting units **244A** of the first substrate supporting section **241A** of the scribing unit section **240** are synchronized

and circled at the same circling speed in the substrate carry-out direction. Concurrently, the clamp devices **251** of the scribing unit section **240** are lowered to a predetermined position such that the bonded mother substrate **90** moves to the scribing unit section, the predetermined position being below the timing belts of the plurality of the first substrate supporting units **244A** of the first substrate supporting section **241A.**

[00296] The scribing unit section **240** has a similar structure to the substrate cutting system **1** in Embodiment 1 except that the substrate carry-out device **80** and the steam unit section **160** are removed from the substrate cutting system in Embodiment 1.

[00297] The cutting device guide body **242** of the scribing unit section **240** is fixed so as to be located above the mounting base **250** along a direction perpendicular to the Y direction in a horizontal state. The first substrate supporting section **241A** and the second substrate supporting section **241B** are fixed to the mounting base **250** via two pillars **246,** respectively, so as to be located on both sides of the cutting device guide body **242** with respect to the cutting device guide body **242**.

[00298] The first substrate supporting section **241A** and the second substrate supporting section **241B** includes the plurality of substrate supporting units **244A** and the plurality of second substrate supporting units **244B,** respectively. Each of the plurality of first substrate supporting units **244A** and each of the plurality of second substrate supporting units **244B** are structured so as to be linear along a direction (Y direction) parallel to a frame **243A** and a frame **243B**, respectively.

[00299] The first substrate supporting section **241A** includes the plurality of first substrate supporting units **244A**. Each of the first substrate supporting units **244A** is held by a holding plate **245**. The holding plates **245** are attached to the top surface

of the mounting base **250**. The first substrate supporting units **244A** are arranged above the mounting base **250.**

[00300] Each one of the first substrate supporting units **244A** provided on the first substrate supporting section **241A** is similar to the first substrate supporting unit **21A** shown in Figure **6** according to Embodiment 1. The timing belt of each of the first substrate supporting units **244A** is circled when the motor included in the first substrate supporting section **241A** rotates about the rotation axis.

[00301] The plurality of first substrate supporting units **244A** is arranged with a predetermined interval therebetween. The timing belt included in each of the first substrate supporting units **244A** is circled clockwise or anti-clockwise at a predetermined circling speed when a control section (not shown) for controlling the substrate cutting system **200** according to the present invention instructs and controls the rotation speed and the rotation direction of the rotation axis of the motor. The circling speed of the timing belt varies.

[00302] The second substrate supporting section **241B** includes the plurality of second substrate supporting units **244B**. The structure of the second substrate supporting unit **244B** is similar to that of the first substrate supporting unit **244A**. The second substrate supporting units **244B** are held by the holding plates **245** such that the first substrate supporting units **244A** and the second substrate supporting units **244B** are attached on opposite sides with respect to the cutting device guide body **242** and attached in the opposite direction with respect to the Y direction. The holding plates **245** are attached to the top surface of the mounting base **250**. The second substrate supporting units **244B** are arranged above the mounting base **250.**

[00303] Above the mounting base **250**, clamp devices **251** are provided for clamping the bonded mother substrate **90** supported on the first substrate supporting section **241A**. For example, as shown in Figure **32**, the clamp devices **251** are arranged with a predetermined interval therebetween along a direction perpendicular to the frame **243B** in order to clamp the side edge of the bonded mother substrate **90** on the substrate carry-in side.

[00304] The structure of each clamp device **251** is similar to that of the clamp device **50** shown in Figure **2** according to Embodiment 1. Each of the clamp devices **251** includes a clamp member **51** for clamping a side edge of the bonded mother substrate **90**. The clamp members **51** are attached to holding members **58** joined to rods **56** of cylinders **55**, which are attached to the movement base **57**, and are moved upward and downward due to the driving of the cylinders **55**.

[00305] When the bonded mother substrate **90** is transported from the positioning unit section **220** to the scribing unit section **240**, the clamp members **51** of the clamp devices **251** are lowered to a predetermined position due to the cylinders **55**, the predetermined position being below the timing belts of the plurality of first substrate supporting units **244A** of the first substrate supporting section **241A**.

[00306] Each of the clamp devices **251** is slid along the Y direction, by a movement mechanism similar to that according to Embodiment 1, between two first substrate supporting units **244A** of the plurality of first substrate supporting units **244A** which are arranged with a predetermined interval therebetween, each of the two first substrate supporting units **244A** being arranged on either side of the remaining plurality of first substrate supporting units **244A**.

[00307] The operation of the clamp member of each of the clamp devices members **251** is as described with reference to Figures **10** and **11** according to Embodiment 1, and thus, the description thereof is omitted herein.

[00308] The arrangement of the clamp devices **251** is not limited to a case when the clamp devices **251** for holding the bonded mother substrate **90** are provided on the frame **243B** and on the substrate carry-in side in a direction perpendicular to the frame **243B**. However, even when the clamp devices **251** are only provided on the frame **243B**, the bonded mother substrate **90** is held without sustaining any damage.

[00309] The clamp device **251** described above only shows one example used in a substrate cutting system according to the present invention. Thus, the clamp devices **251** are not limited to these. In other words, a clamp device can be arbitrary, as long as the clamp device has a structure for gripping or holding the side edge of the bonded mother substrate **90**. For example, when the size of the substrate is small, the substrate is held by clamping one part of the side edge of the substrate, thereby the substrate being cut without causing any defect to the substrate.

[00310] An upper substrate cutting device **60** in Embodiment 1 shown in Figure **3** is attached to the upper guide rail **252** of the cutting device guide body **242**. A lower substrate cutting device **70** is attached to the lower guide rail **253**, the lower substrate cutting device **70** having a similar structure to the upper substrate cutting device **60** in Embodiment 1 shown in Figure **4** and being in a state of inversion to the upper substrate cutting device **60** in a vertical direction. The upper substrate cutting device **60** and the lower substrate cutting device **70** slide along the upper guide rail **252** and the lower guide rail **253**, respectively, due to linear motors.

[00311] For example, in the upper substrate cutting device **60** and the lower substrate cutting device **70**, cutter wheels **62a** for scribing a bonded mother substrate **90** are rotatably attached to tip holders **62b**, respectively, the cutter wheels being similar to those shown in Embodiment 1 in Figures **3** and **4.** Furthermore, the tip holders **62b** are rotatably attached to respective cutter heads **62c** with a direction vertical to top and bottom surfaces of the bonded mother substrate **90** held by the clamp devices **251** at its axis. The cutter heads **62c** are movable along a direction vertical to top and bottom surfaces of the bonded mother substrate **90** by a driving means (not shown). A load is applied to the cutter wheels **62a**, as appropriate, by an energizing means (not shown).

[00312] As the cutter wheel **62a** held by the tip holder **62b**, a cutter wheel which has a blade edge with the center in the width direction protruded in an obtuse V shape is used as disclosed in Japanese Laid-Open Publication No. 9-188534. The protrusions with a predetermined height are formed on the blade edge with a predetermined pitch in the circumferential direction.

[00313] The lower substrate cutting device **70** provided on the lower side guide rail **253** has a structure similar to the upper substrate cutting device **60**, but is provided in an inverted state thereto. The cutter wheel **62a** (see Figure **4**) of the lower substrate cutting device **70** is arranged so as to face the cutter wheel **62a** of the upper substrate cutting device **60.**

[00314] The cutter wheel **62a** of the upper substrate cutting device **60** is pressed so as to make contact onto the top surface of the bonded mother substrate **90** by the aforementioned energizing means and the moving means of the cutter head **62c.** The cutter wheel **62a** of the lower substrate cutting device **70** is pressed so as to make contact onto the bottom surface of the bonded mother substrate **90** by the

aforementioned energizing means and the moving means of the cutter head **62c**. When the upper substrate cutting device **60** and the lower substrate cutting device **70** are simultaneously moved in the same direction, the bonded mother substrate **90** is cut.

[00315] It is preferred that the cutter wheel **62a** is rotatably supported by the cutter head **65** using the servo motor disclosed in WO 03/011777.

[00316] Figure **12** shows a side view of the cutter head **65** and Figure **13** shows a front view of the important constituents thereof as one example of the cutter head **65** using the servo motor. The servo motor **65b** is supported in an inverted manner between a pair of side walls **65a**. A holder holding member **65c** is provided below the pair of side walls **65a** so as to be rotatable via a supporting axis **65d,** the holder holding member **65c** having an L shape when viewed from the side. A tip holder **62b** is attached in front (on the right-hand side in Figure **13**) of the holder holding member **65c**. The tip holder **62b** is attached to rotatably support the cutter wheel **62a** via an axis **65e.** Flat bevel gears **65f** are mounted on the rotation axis of the servo motor **65b** and the supporting axis **65d** so as to engage with each other. Thus, the holder holding member **65c** performs an upwards and downwards tilt operation with the supporting axis **65d** as its supporting point and the cutter wheel **62a** moves upwards and downwards due to the forward and reverse rotation of the servo motor **65b**. The cutter heads **65** themselves are provided on the upper substrate cutting device **60** and the lower substrate cutting device **70**.

[00317] Figure **14** is a front view showing another example of cutter head using a servo motor. The rotation axis of the servo motor **65b** is directly connected to the holder member **65c**.

[00318] The cutter heads shown in Figures **12** and **14** move the cutter wheels **62a** upwards and downwards by rotating the servo motors using the position control so as to position the cutter wheel **62a**. The cutter heads transmit the scribing pressure for the brittle material substrate to the cutter wheel **62a** by controlling the rotation torque. The rotation torque acts to return the cutter wheel **62a** to the set position when the position of the cutter wheel **62a** is shifted from the positions previously set in the servo motors **65b** during the scribing operation for forming a scribing line on the bonded mother substrate **90** by moving the cutter heads in a horizontal direction. In other words, the servo motor **65b** controls the position in the perpendicular direction of the cutter wheel **62a,** and at the same time, the servo motor **65b** is an energizing means for the cutter wheel **62a**.

[00319] By using the cutter head including the aforementioned servo motor, when the bonded mother substrate **90** is being scribed, the rotation torque of the servo motor is corrected immediately in response to the change of the scribing pressure by the change in resistive force received by the cutter wheel **62a.** Thus, scribing is stably performed and a scribing line with excellent quality can be formed.

[00320] A cutter head is effectively applied to cutting the mother substrate in the substrate cutting system according to the present invention. The cutter head includes a mechanism for vibrating a scribing cutter (e.g., a diamond point cutter or a cutter wheel) which scribes the bonded mother substrate **90** so as to periodically change the pressure force of the scribing cutter on the bonded mother substrate **90**.

[00321] The structure of the upper substrate cutting device **60** and the lower substrate cutting device **70** is not limited to the aforementioned structure. In other words, any structure can be used, as long as the device has a structure for processing the top and bottom surfaces of the substrate so as to cut the substrate.

[00322] For example, the upper substrate cutting device **60** and the lower substrate cutting device **70** can be a device which cuts the mother substrate by using such as a laser light, a dicing saw, a cutting saw or a diamond-studded blade cutter. When the mother substrate is made of a metal substrate (e.g., a steel plate), a wood plate, a plastic substrate or a brittle material substrate (e.g., a ceramic substrate, glass substrate or semiconductor substrate), a substrate cutting device for cutting the mother substrate by using, for example, a laser light, a dicing saw, a cutting saw, or a diamond-studded blade cutter is used.

[00323] Furthermore, when a bonded mother substrate for which a pair of mother substrate is bonded to each other, a bonded mother substrate for which different types of mother substrates are bonded to each other or a stacked substrate for which a plurality of mother substrates are stacked on each other is cut, a substrate cutting device similar to the one used for cutting the aforementioned mother substrate can be used.

[00324] The upper substrate cutting device **60** and the lower substrate cutting device **70** may include a cutting assistance means for assisting the cutting of the substrate. As a cutting assistance means, for example, a means for pressing (e.g., a roller on the substrate), a means for spraying compressed air onto the substrate, a means for irradiating a laser onto the substrate or a means for warming (heating) the substrate by spraying such as heated air onto the substrate is used.

[00325] Furthermore, in the description above, the upper substrate cutting device **60** and the lower substrate cutting device **70** have the same structure. However, the upper substrate cutting device **60** and the lower substrate cutting device **70** can have structures different from each other, depending on the cutter pattern of the substrate or the cutting condition of the substrate.

[00326] The buffer conveyor section **260** transports the processed bonded mother substrate **90** to the steam break unit section **280,** the bonded mother substrate **90** being mounted on the plurality of second substrate supporting units **244B** of the second substrate supporting section **241B** after the bonded mother substrate **90** is scribed by the upper substrate cutting device **60** and the lower substrate cutting device **70** of the cutting device guide body **242** of the scribing unit section **240** and the clamping (holding) of the bonded mother substrate **90** by the clamp devices **251** are released.

[00327] The buffer conveyor section **260** has a similar structure to that of the first substrate supporting section **241A** of the scribing unit section **240.** Alternatively, the buffer conveyor section **260,** which is a flat-belt made of woven cloth, metal or rubber, is structured so as to be circle along the Y direction due to the motor driven by the control section in the substrate cutting system **200** according to the present invention (flat belt in Figure **32**).

[00328] The scribed bonded mother substrate **90** mounted on the timing belts of the plurality of second substrate supporting units **244B** of the second substrate support section **241B** is transported onto a belt **261** of the buffer conveyor section **260** when the timing belt of each of the plurality of second substrate supporting units **244B** of the second substrate supporting section **241B** of the scribing unit section **240** and the belt **261** of the buffer conveyor section **260** are synchronized and circled at the same circling speed in the substrate carry-out direction.

[00329] The scribed bonded mother substrate **90** transported onto the belt **261** of the buffer conveyor section **260** is transported to a steam break unit section **280** when the belt **261** of the buffer conveyor section **260** and a belt of a belt conveyor **285,** which is provided on the substrate carry-out side of the steam break unit section

280, are synchronized and circled at the same circling speed in the substrate carry-out direction.

[00330] The steam break unit section **280** has a structure similar to the steam unit section **160** in Embodiment 1 shown in Figure **8** except that the steam break unit section **280** does not move along the Y direction and is fixed.

[00331] In the steam break unit section **280**, an upper steam unit attachment bar **281** and a lower steam unit attachment bar **282** are attached to pillars **283,** respectively, along the X direction, parallel to the cutting device guide body **242.** The upper steam unit attachment bar **281** attaches a plurality of steam units **284** for spraying steam onto the mother substrate **91** on the upper side of the bonded mother substrate **90**. The lower steam unit attachment bar **282** attaches a plurality of steam units **284** for spraying steam onto the mother substrate **92** on the lower side of the bonded mother substrate **90.**

[00332] Each pillar **283** on the respective frame **243A** and **243B** sides of the scribing unit section **240** is joined to the upper surface of the mounting base **270**, respectively. A belt conveyor **285** is provided on the substrate carry-out side of the steam break unit section **280** after the steam is sprayed onto top and bottom surfaces of the bonded mother substrate **90** from the steam unit **284.** The belt conveyor is provided with, for example, a sheet belt which circles, and supports and transports the completely cut bonded mother substrate **90.**

[00333] The circling speed of the belt conveyor **285** provided on the substrate carry-out side of the steam break unit section **280** is set at approximately the same circling speed of the buffer conveyor section **260** and moves in synchronization therewith.

[00334] The steam break unit section **280** has a structure similar to the steam unit section **160** in Embodiment 1 shown in Figure **8**. A plurality of steam units **284** is attached to the upper steam unit attachment bar **281**. The plurality of steam units **284** is attached to the lower steam unit attachment bar **282** with a gap GA with respect to the plurality of steam units **284** on the upper side. The gap GA is adjusted such that the bonded mother substrate **90** passes through the gap GA.

[00335] The structure of the steam unit **284** is similar to that of the steam unit section **160** in Embodiment 1 shown in Figure **9**. The steam unit **284** is almost entirely constructed by an aluminum material. A plurality of heaters **161a** is embedded in the steam unit **284** in a perpendicular direction. When an open/close valve, which automatically opens and closes, is opened, water flows into the steam unit **284** from a water supplying opening **161b.** The water is heated by the heater **161a** and the supplied water vaporizes into steam. The steam is sprayed toward the surface of the mother substrate from a gushing opening **161d** through a duct hole **161c**.

[00336] An air knife **286** is provided on the carry-out side of the upper steam unit attachment bar **281**. The air knife **286** is provided for removing the moisture that remains on the surface of the mother substrate **90** after the steam is sprayed onto the upper surface of the mother substrate **90**.

[00337] A steam unit **284** and the air knife **286** similar to those attached to the upper steam unit attachment bar **281** are provided in the lower steam unit attachment bar **282.**

[00338] After the scribed bonded mother substrate **90** mounted on the second substrate supporting units is transported onto the belt **261** of the buffer conveyor section **260,** the belt **261** of the buffer conveyor section **260** and the belt of the belt conveyor **285,** which is provided on the substrate carry-out side of the steam break

unit section **280,** are synchronized and circled at the same circling speed in the substrate carry-out direction. Thus, the scribed bonded mother substrate **90** passes through the steam break unit section **280** and is cut into panel substrates **90a** and the panel substrates **90a** are suspended on the belt conveyor **285.**

[00339] The substrate transportation unit section **300** lifts the panel substrates **90a,** which is moving or stopped, supported by the belt conveyor **285,** and mounts the panel substrates **90a** on a panel supporting section **322** of an inversion transportation robot **321** of a panel inversion unit section **320,** when the bonded mother substrate **90** passes through the steam break unit section **280** and is cut.

[00340] Above the mounting base **270** and the mounting base **330** of the substrate transportation unit section, a substrate carry-out device guide **301** is constructed. The substrate transportation device guide **301** is capable of moving the transportation robot **310,** which transports the panel substrates cut from the bonded mother substrate **90**, in the X direction in parallel to the steam break unit section **280** and the cutting device guide body **242**, perpendicular to the flow direction of the substrate in the Y direction. In the substrate carry-out unit section **300**, along guides **303** on the frame **243A** side and on the frame **243B** side provided on each respective top surface of the mounting base **270** and the mounting base **330** via pillars **302,** both ends of the substrate carry-out device guide **301** slide due to linear motors via respective supporting members **304.** In this case of the linear motors, movers (not shown) of the linear motors are inserted in the stators for the linear motors, provided on the respective guides **303.** The movers for the linear motors are attached to the supporting members **304**.

[00341] An adsorption section (not shown) is provided on the carry-out robot **310.** The adsorption section adsorbs, by suction, each panel substrate **90a** that is cut

from the bonded mother substrate **90**. While the panel substrate **90a** is in a state of being adsorbed by the adsorption section, when the transportation robot **310** is slid to the substrate carry-out side, each panel substrate **90a** is mounted on the panel supporting section **322** of the inversion transportation robot **321** in the panel inversion unit section **320.**

[00342] The structure of the carry-out robot **310** in the substrate transportation unit section **300** is similar to that of the carry-out robot **140** in Embodiment 1 shown in Figure **5**. Thus, the detailed description thereof will be omitted herein. The carry-out robot **310** is attached to the substrate carry-out device guide **301**. The carry-out robot **310** is movable by a moving mechanism in a direction (X direction) along the substrate carry-out device guide **301**, the moving mechanism combining a driving means due to a linear motor or a servo motor and a straight-line guide.

[00343] In the transportation of each of the panel substrates **90a** that is cut from the bonded mother substrate **90** by the transportation robot **310**, the cut panel substrate **90a** is held by the adsorption pads on the carry-out robot **310** due to the suction of a suction mechanism (not shown). After the entire carry-out robot **310** is moved upward by an up-and-down moving mechanism (not shown) once, each of the panel substrates **90a** is transported to the inversion transportation robot **321** in the panel inversion unit section **320** for the next step. Thereafter, the carry-out robot **310** is moved downward by the up-and-down moving mechanism (not shown) again and then, each of the panel substrates **90a** is mounted on a predetermined position of the panel holding section **322** of the inversion transportation robot **321** in the panel inversion unit section **320** in a predetermined state in the next step.

[00344] An inversion panel robot **321** is provided in the panel inversion unit section **320.** The inversion panel robot **321** receives the panel substrate **90a** from the carry-

out robot **310** of the substrate transportation unit section **300,** inverts the sides (top and bottom) of the panel substrates **90a** and mounts the panel substrate **90a** on a separation table **341** of a panel terminal separation section **340**.

[00345] The panel holding section **322** of the inversion transportation robot **321** includes, for example, a plurality of adsorption pads. The panel holding section **322** is rotatably supported with respect to a robot body section **323** of the inversion transportation robot **321.**

[00346] Referring to the panel substrates **90a** mounted, by the inversion transportation robot **321,** on the separation table **341** of the panel terminal separation section **340**, for example, an undesired portion **99** of the panel substrates **90a** is separated from the panel substrate **90a** by an undesired portion removal mechanism **342** which is provided in the vicinity of each side edge of the separation table **341,** as shown in Figure **36,** whereby the undesired portion removal mechanism **342** is provided by an insertion robot (not shown).

[00347] In the undesired portion removal mechanism **342**, as shown in Figure **36,** a plurality of removal roller sections **342a** is arranged with a predetermined pitch along each side edge of the separation table **341**, each of the plurality of removal roller sections **342a** having a pair of rollers **342b** facing each other. Each roller **342b,** facing each other, provided on each removal roller section **342a** is energized in a direction so as to approach each other. The undesired portion **99** on the upper side of the panel substrate **90a** of the substrate and the side edge on the lower side of the panel substrate **90a** are inserted between each roller **342b** by the insertion robot (not shown). Each roller **342b** rotates only in one direction in which the panel substrate **90a** is inserted between each roller **342b**. The pair of rollers **342b** facing

each other is set such that the rotating directions thereof are opposite with respect to each other.

[00348] The operation of the substrate cutting system, having such a structure, according to Embodiment 2 will be described, mainly using a case in which a bonded substrate for which large-sized glass substrates are bonded to each other is cut. When a bonded mother substrate **90** for which large-sized glass substrates are bonded to each other is cut into a plurality of panel substrates **90a** (see Figure **16**), as shown in Figure **37**, a transportation device (not shown) in the previous step mounts the bonded mother substrate **90** on the belt **221e** of each of the plurality of substrate supporting bases **221** of the positioning unit section **220** according to Embodiment 2.

[00349] Thereafter, a plurality of supporting bases **221,** which supports the bonded mother substrate **90,** lowers, by up-and-down moving device **222,** to a height, from which the substrate of the substrate cutting system according to the present invention is transported by a conveyor.

[00350] As shown in Figure **38**, while the bonded mother substrate **90** is mounted on the belt **221e** of each of the substrate supporting bases **221**, the belt **221e** of each of the substrate supporting bases **221** is circled toward the substrate carry-in side, and the side edge of the bonded mother substrate **90** on the substrate carry-in side is contacted to a plurality of reference rollers **223** provided in a guide bar **225** of the positioning unit section **220**.

[00351] After the side edge of the bonded mother substrate **90** on the substrate carry-in side is contacted to a plurality of reference rollers **223** provided in the guide bar **225** of the positioning unit section **220,** the bonded mother substrate **90** is pushed toward reference rollers **223** of a guide bar **226** by pushers **224** of a guide bar **227**

of the positioning unit section **220,** and the side edge of the bonded mother substrate **90** on the guide bar **226** is contacted to the reference roller **223** provided on the guide bar **226.** Thus, the bonded mother substrate **90** is positioned on the belts **221e** of the substrate supporting bases **221**.

[00352] Thereafter, the push of the bonded mother substrate **90** toward the reference rollers **223** of the guide bar **226** by the pushers **224** of the guide bar **227** of the positioning unit section **220** is stopped. The bonded mother substrate **90** positioned by the positioning unit section **220** is moved toward a position where the bonded mother substrate **90** on the first substrate supporting section **241A** of the scribing unit section **240** is clamped by the clamp devices **251** when the belt **221e** of each of the substrate supporting bases **221** of the positioning unit section **220** and the timing belt of each of the plurality of first substrate supporting units **244A** of the first substrate supporting section **241A** of the scribing unit section **240** are synchronized and circled at the same circling speed in the substrate carry-out direction. Thereafter, the side edge of the bonded mother substrate **90** on the substrate carry-in side is clamped by the clamp devices **251.**

[00353] When the bonded mother substrate **90** is transported from the positioning unit section **220** to the scribing unit section **240,** the clamp members **51** of the clamp devices **251** wait at a predetermined position which is below the timing belts of the plurality of first substrate supporting units **244A** of the first substrate supporting section **241A**. After the bonded mother substrate **90** is transported to a position where it is held by the clamp devices **251,** the clamp members **51** move upward and grip the side edge of the bonded mother substrate **90.**

[00354] As shown in Figure **39,** when the side edge of the bonded mother substrate **90** on the mother substrate carry-in side is clamped by the clamp devices **251,** each

clamp member, which clamps the side edge of the bonded mother substrate **90,** lowers at approximately the same time due to the weight of the bonded mother substrate **90**. Therefore, the bonded mother substrate **90** is additionally supported by the timing belts of all the first substrate supporting units **244A.**

[00355] Each of the clamp devices **251** holding the bonded mother substrate **90** is moved toward the substrate carry-out side such that the cutting device guide body **242** is located at a predetermined position above the side edge of the bonded mother substrate **90** on the substrate carry-out side, the bonded mother substrate **90** being clamp in a horizontal state by the clamp devices **251**. Simultaneous to when each of the clamp devices **251** starts moving toward the substrate carry-out side, the timing belt of each of the first substrate supporting units **244A** and the timing belt of each of the second substrate supporting units **244B** are circled in the substrate carry-out direction at the same circling speed as the moving speed of each of the clamp devices **251**. After each of the clamp devices **251** completed the movement to the substrate carry-out side, the circling of the timing belt of each of the first substrate supporting units **244A** and the timing belt of each of the second substrate supporting units **244B** is stopped.

[00356] A first optical device and a second optical device provided on the cutting device guide body **242** move along the cutting device guide body **242A** from respective waiting positions and capture a first alignment mark and a second alignment mark, respectively, provided on the bonded mother substrate **90**.

[00357] When each of clamp devices holding the bonded mother substrate **90** slides, the timing belts **21**e of the first substrate supporting units **244A** of the first substrate supporting section **241A** and the timing belts **21e** of the second substrate supporting units **244B** of the second substrate supporting section **241B** are rotated at the same

circling speed of each of the clamp devices **251** in the same direction as the moving direction of each of the clamp devices **251.** Thus, the bonded mother substrate **90** held by the clamp devices **251** is supported, without being rubbed against the timing belts, by the timing belts of the first substrate supporting units **244A** of the first substrate supporting section **241A** and the timing belts of the second substrate supporting units **244B** of the second substrate supporting section **241B.**

[00358] Next, based on the result of the captured first alignment mark and second alignment mark, the inclination of the bonded mother substrate **90** with respect to the cutting device guide body **242,** the starting position of cutting the bonded mother substrate **90** and the ending position of cutting the bonded mother substrate **90** are calculated by an operational processing device (not shown), the bonded mother substrate **90** being supported by the clamp devices **251** in a horizontal state. Based on the result of the calculation, each of the clamp devices **251** as well as the upper substrate cutting device **60** and the lower substrate cutting device **70** are moved so as to cut the bonded mother substrate **90** (which is referred to as "scribing by linear interpolation" or "cutting" by linear interpolation).

[00359] In this case, each cutter wheel **62a** facing each other is pressed so as to make contact onto the top surface and the bottom surface of the bonded mother substrate **90** and rolled on the top surface and the bottom surface of the bonded mother substrate **90**, respectively, so as to form scribing lines **95** on the top surface and the bottom surface of the bonded mother substrate **90**.

[00360] Figure **40** is a view showing a state in which each of the second substrate supporting section **241B** supports the bonded mother substrate after the scribing lines **95** are formed at the side edge of four panel substrates **90a** in order to cut four panel substrates from the bonded mother substrate **90** by pressing and rolling the

cutter wheel **62a** of the upper substrate cutting device **60** and the cutter wheel **62a** of the lower substrate cutting device **70.**

[00361] The bonded mother substrate **90** is, for example, as shown in Figure **40,** cut so that two panel substrates **90a** are cut into two lines in a direction along the upper guide rail **252** and the lower guide rail **253**. The cutter wheel **62a** of the upper substrate cutting device **60** and the cutter wheel **62a** of the lower substrate cutting device **70** are pressed so as to make contact and rolled along the side edge of the display panels **90a** in order to cut four panel substrates **90a** from the bonded mother substrate **90.**

[00362] In this case, vertical cracks are created, by the cutter wheel **62a** of the upper substrate cutting device **60** and the cutter wheel **62a** of the lower substrate cutting device **70** on the part where each cutter wheel **62a** is respectively pressed so as to make contact each glass substrate and rolled on each glass substrate. As a result, scribing lines **95** are formed thereon. Protrusions are formed, with a predetermined pitch, on the blade edge of each cutter wheel **62a** in a circumferential direction. Thus, a vertical crack having about 90% of thickness of the glass substrate in the thickness direction is formed on each glass substrate.

[00363] A scribing method is effectively applied to cutting the bonded mother substrate **90** in the substrate cutting system according to the present invention, the scribing method using the cutter head including a mechanism for vibrating a scribing cutter (e.g., a diamond point cutter or a cutter wheel), which scribes the bonded mother substrate **90** so as to periodically change the pressure force of the scribing cutter on the bonded mother substrate **90**.

[00364] When scribing the top and bottom surfaces of the bonded mother substrate **90** is completed and the state shown in Figure **40** is formed, then the clamping

(holding) of the bonded mother substrate **90** by the clamp devices **251** are released, and the bonded mother substrate **90** is mounted on the second substrate supporting section **241B**.

[00365] Regarding a scribing method for forming a scribing line on a side edge of each of four panel substrates **90a** in order to cut the four panel substrates **90a** from the bonded mother substrate **90** by pressing and rolling the cutter wheel **62a** of the upper substrate cutting device **60** and the cutter wheel **62a** of the lower substrate cutting device **70**, respectively, the scribing method according to Embodiment 1 shown in Figures **17** to **19** is effectively applied to the substrate cutting system according to Embodiment 2, other than the substrate cutting system shown in Figure **40**.

[00366] After the bonded mother substrate **90** is scribed by the upper substrate cutting device **60** and the lower substrate cutting device **70** of the cutting device guide body **242** of the scribing unit section **240**, the clamping (holding) of the bonded mother substrate by the clamp devices **251** is released, the scribed bonded mother substrate **90** is placed into a state where it is only supported by the plurality of second substrate supporting units **244B** of the second substrate supporting section **241B**.

[00367] The scribed bonded mother substrate **90** supported on the timing belts of the plurality of second substrate supporting units **244B** of the second substrate supporting section **241B** is transported onto the belt **261** of the buffer conveyor section **260** when the timing belt of each of the plurality of second substrate supporting units **244B** of the second substrate supporting section **241B** of the scribing unit **240** and the belt **261** of the buffer conveyor section **260** are

synchronized and circled at the same circling speed in the substrate carry-out direction.

[00368] The scribed bonded mother substrate **90** transported onto the belt **261** of the buffer conveyor section **260** is transported to the steam break unit section **280** when the belt **261** of the buffer conveyor section **260** and the belt of the belt conveyor **285,** which is provided on the substrate carry-out side of the steam break unit section **280,** are synchronized and circled at the same circling speed in the substrate carry-out direction.

[00369] In the steam break unit section **280**, an upper steam unit attachment bar **281** and a lower steam unit attachment bar **282** are attached to pillars **283** along the X direction in parallel to the cutting device guide body **242.** The upper steam unit attachment bar **281** attaches a plurality of steam units **284** for spraying steam onto the mother substrate **91** on the upper side of the bonded mother substrate **90**. The lower steam unit attachment bar **282** attaches a plurality of steam units **284** for spraying steam onto the mother substrate **92** on the lower side of the bonded mother substrate **90.**

[00370] The circling speed of the belt conveyor **285** provided on the substrate carry-out side of the steam break unit section **280** is set at approximately the same circling speed of the timing belt **261e** of the buffer conveyor section **260.** When the belt conveyor **285** circles in synchronization with the timing belt **261e** of the buffer conveyor section **260,** the scribed bonded mother substrate **90** passes through the steam break unit section **280.**

[00371] An air knife **286** is provided on the upper steam unit attachment bar **281** on the substrate carry-out side. A steam unit **284** and an air knife **286** that are similar to the air knife attached to the upper steam unit attachment bar **281** are provided on

the lower steam unit attachment bar **282**. Thus, after steam is sprayed on the top and bottom surfaces of the bonded mother substrate **90,** the moisture remaining on the top and bottom surfaces of the bonded mother substrate **90** is completely removed.

[00372] After the scribed bonded mother substrate **90** mounted on the second substrate supporting units is transported onto the belt of the buffer conveyor section **260,** the belt of the buffer conveyor section **260** and the belt of the belt conveyor **285,** which is provided on the substrate carry-out side of the steam break unit section **280,** are synchronized and circled at the same circling speed in the substrate carry-out direction. Thus, the scribed bonded mother substrate **90** passes through the steam break unit section **280** and are cut into panel substrates **90a** and the panel substrates **90a** are suspended on the belt conveyor **285.**

[00373] The bonded mother substrate **90** is cut into a plurality of panel substrates **90a** when it passes through the steam break unit section **280**. The panel substrates **90a** which is moving or stopped, supported by the belt conveyor **285** are lifted by the carry-out robot **310** and mounted on the panel supporting section **322** of the inversion transportation robot **321** of the panel inversion unit section **320**.

[00374] The inversion panel robot **321** of the panel inversion unit section **320** receives the panel substrates **90a** from the carry-out robot **310** of the substrate transportation unit section **300,** inverts the sides (top and bottom) of the panel substrates **90a** and mounts the panel substrates **90a** on the separation table **341** of the panel terminal separation section **340**.

[00375] Referring to the panel substrates **90a** mounted, by the inversion transportation robot **321,** on the separation table **341** of the panel terminal separation section **340,** for example, an undesired portion **99** of the panel substrates

90a is separated from the panel substrate **90a** by an undesired portion removal mechanism **342** which is provided in the vicinity of each side edge of the separation table **341**, as shown in Figure **40**, whereby the undesired portion removal mechanism **342** is, for example, provided by an insertion robot (not shown).

[00376] By employing the scribing method according to Embodiment 1 shown in Figure **22** to Figure **31** as the scribing method by the upper substrate cutting device **60** and the lower substrate cutting device **70** of the cutting device guide body **242**, a cutting step of the bonded substrate **90** by the steam unit section **280** can be omitted.

[00377] Further, as a method for cutting the substrate, a method in which double scribing lines are formed on the bonded mother substrates, for which glass substrates which are one type of brittle material substrate are bonded as mother substrates, has been described as an example. However, the present invention is not limited to this. When the mother substrate is made of a metal substrate (e.g., a steel plate), a wood plate, a plastic substrate or a brittle material substrate (e.g., a ceramic substrate, glass substrate or semiconductor substrate), a substrate cutting method for cutting the mother substrate by using, for example, a laser light, a dicing saw, a cutting saw, or a diamond-studded blade cutter is used.

[00378] Furthermore, the substrate according to the present invention includes, other than mother substrate, a bonded substrate for which mother substrates are bonded to each other, a bonded substrate for which different mother substrates are combined and bonded to each other, and a stacked substrate for which mother substrates are combined and stacked on each other.

EMBODIMENT 3

[00379] A substrate manufacturing apparatus **801** shown in Figure **41** is obtained by connecting a substrate chamfering system **600** for chamfering end surfaces of the cut substrates to one of the substrate cutting systems **1** and **200** according to the present invention. Furthermore, the substrate manufacturing apparatuses **802** and **803** shown in Figure **42** are obtained by incorporating an inspection system **700** for inspecting the size, conditions of the top and bottom surfaces, end surfaces, and the like of the cut substrates and for inspecting the functions of the substrates into the substrate manufacturing apparatus **801** described above.

[00380] In the above description of the operations of the substrate cutting systems according to Embodiments 1 and 2, examples in which the bonded mother glass substrate formed by bonding glass substrates to each other is cut have been described. However, the present invention is not limited to these. For example, operations different from the above description can be performed depending on the types of the substrates to be cut or in order to enhance the functionalities of the devices which constitute the substrate cutting system.

[00381] In the above description of Embodiments 1 and 2, the substrate cutting systems for cutting the bonded mother substrate formed by bonding glass substrates to each other into a plurality of display panels have been mainly described. However, the substrate which can be applied to the present invention is not limited to this. The substrate used in the substrate cutting system according to the present invention includes a metal substrate (e.g., a steel plate), a wood plate, a plastic plate and a brittle material substrate (e.g., a ceramic substrate, a semiconductor substrate and a glass substrate) as a mother substrate. Furthermore, the substrate used in the substrate cutting system according to the

present invention includes a bonded substrate for which mother substrates are bonded to each other, a bonded substrate for which different mother substrates are combined and bonded to each other, and a stacked substrate for which mother substrates are combined and stacked on each other.

[00382] The substrate cutting system can be applied to the cutting of the mother substrate for a PDP (plasma display) used for an FPD (flat panel display)), a liquid crystal display panel, a reflective projector panel, a transmissive projector panel, an organic EL device panel, an FED (field emission display) and the like as a bonded brittle mother substrate for which brittle material substrates are bonded to each other.

EMBODIMENT 4

[00383] A substrate cutting system according to Embodiment 4 has a similar structure to the substrate cutting system according to Embodiment 2 except that the structure of the first substrate supporting section **241A** and the second substrate supporting section **241B** is different from each other. As shown in Figure **44**, in the first substrate supporting section **241A** according to Embodiment **4**, first substrate floating units **29A** are provided between the first substrate supporting units **244A** adjacent to each other. The structure of the first substrate supporting unit **244A** is similar to that in Embodiment 2. The first substrate supporting section **241A** and the second substrate supporting section **241B** configure a substrate supporting device.

[00384] The first substrate floating units **29A** other than those arranged on both sides of the first substrate supporting section **241A**, respectively, have a similar structure to each other. Figure **45** is a plane view showing the first substrate floating unit **29A**. Figure **46** is a side view thereof. Figure **47** is a longitudinal-sectional view thereof. The first substrate floating unit **29A** includes a horizontal table arranged

between the first substrate supporting units **244A** adjacent to each other; and buffer heads **292** arranged in two columns in the table **291** along the Y direction. The size of the table **291** in the width direction is approximately the same as the space between the first substrate supporting units **244A** adjacent to each other. In each of the first substrate floating units **29A** arranged on both sides of the first substrate supporting section **241A**, respectively, the size of the table **291** in the width direction is shortened such that a gap is formed, through each of the clamp devices **251** can pass between each of the first substrate floating units **29A** respectively provided on both sides of the first substrate supporting section **241A** and each of the respective first substrate supporting units **244A** respectively provided on both sides of the first substrate supporting section **241A.**

[00385] Each of the buffer heads **292**, as shown in Figure **47**, includes: an air gushing rod **293** attached in a vertical state with respect to the table **291** so as to be movable in the up-and-down direction; and a disk-shaped buffer pad **294** attached, in the horizontal state, to the top end of the air gushing rod **293,** respectively.

[00386] Each of the air gushing rods **293** is supported by a spring coil **296** so as to be elastically inclinable and movable in the upper-and down direction. The central portion of the axle of the air gushing rod **293** is a hollow air flowing path, and compressed air is supplied to this air flowing path. In the central portion of each of the buffer pad **294,** an air gushing opening **295**, from which the compress air supplied to the air flowing path is gushed, is formed, respectively. With the compressed air gushed from each of the air gushing openings **295**, the bonded mother substrate **90** provided thereabove is lifted above.

[00387] The air gushing rod **293** of each of the buffer heads **292** provided in the table **291** is, as shown in Figure **48,** inclinable with respect to the table **291**. Owing to this

structure, due to the gushing of the compressed air (Bernoulli effect), the buffer pads **294** of the buffer heads **292** entirely move in accordance with the bendings or undulations on the mother bonded substrate **90,** and the buffer pads **294** move such that the interval between the bonded mother substrate **90** and each of the buffer pads **294** is maintained constant. The compressed air caused to gush out of each of the air gushing openings **295** flows in layers along the radiation direction of the buffer pad **294**. Therefore, the space between the mother bonded substrate **90** and each of the buffer pads **294** can be maintained constant. As a result, any damage to the back surface of the mother bonded substrate **90** can be prevented, thereby maintaining the state in which the mother bonded substrate **90** stably floats.

[00388] The first substrate floating units **29A** respectively provided on both sides of the first substrate supporting section **241A** have the same structure as that of the rest of the first substrate floating units **29A** except that the size in the width direction of the table **291** is short such that a gap is formed, through each of the clamp devices **251** can pass between each of the first substrate floating units **29A** respectively provided on both sides of the first substrate supporting section **241A** and each of the respective first substrate supporting units **244A** respectively provided on both sides of the first substrate supporting section **241A**; and buffer heads **292** in one column are provided in the table **291** along the Y direction.

[00389] In the present Embodiment, as shown in Figure **44**, in the second substrate supporting section **241B**, second substrate floating units **29B** which are same as the first substrate floating units **29A** are respectively provided between adjacent second substrate supporting units **244B** to each other.

[00390] In the substrate cutting system having such a structure, similar to Embodiment 2, the bonded mother substrate **90** positioned by the positioning unit

section **220** (see Figure **32**) is transported to a predetermined position of the first substrate supporting section **241A** when the positioning unit section **220** and the timing belt of each of the first substrate supporting units **244A** are synchronized and circled.

[00391] In this manner, when the bonded mother substrate **90** is transported to the predetermined position with respect to the cutting device guide body **242**, the side edge of the bonded mother substrate **90,** which is positioned on the substrate carry-in side, is clamped by each of clamp members **51** of the clamp devices **251.**

[00392] Then, compressed air is supplied to the air gushing rod **293** provided on each of the first substrate floating units **29A** and each of the second substrate floating units **29B**, and the compressed air is gushed out of the air gushing opening **295** respectively provided in the central portion of each of buffer pads **294.** Concurrently, each of the clamp members **51** is moved upward to a predetermined height. As a result, the bonded mother substrate **90** clamped by the clamp members **51** is lifted by the compressed air which is gushed out of each of the air gushing openings **295**, thereby the bonded mother substrate **90** being held at the predetermined height by the clamp members **51**.

[00393] Instead of moving the clamp members **51** upward to the predetermined height, it is possible to hold the clamp members **51** so as to be movable in the upward-and-downward direction. Alternatively, it is possible to energize the clamp members **51,** which are held so as to be movable in the upward-and-downward direction, upward with the force equivalent to the weight of each of the clamp members **51** by using an air cylinder or the like. By constructing the clamp member **51** having such a structure, it is possible to cause the clamp members **51** to follow the substrate lifted by the first substrate floating units **29A** and the second substrate

floating units **29B** and move the clamp members **51** in the upward-and-downward direction.

[00394] In this state, a first optical device and a second optical device provided on the cutting device guide body **242,** respectively, capture a first alignment mark and a second alignment mark, respectively, provided on the bonded mother substrate **90**. The inclination of the bonded mother substrate **90** with respect to the cutting device guide body **242,** the bonded mother substrate **90** being supported in the horizontal state by the clamp devices **251,** the starting position of cutting the bonded mother substrate **90** and the ending position of cutting the bonded mother substrate **90** are calculated. Based on the result of the calculation, the clamp devices **251** holding the bonded mother substrate **90** as well as the upper substrate cutting device **60** and the lower substrate cutting device **70** are moved so as to scribe the bonded mother substrate **90.**

[00395] The scribing operation in this case is similar to that in Embodiment 2. The bonded mother substrate **90** clamped by the clamp devices **251** is slid by the clamp devices **251** along the Y direction while it is lifted from the timing belts by the first substrate floating units **29A** and the second substrate floating units **29B**. Concurrently, the bonded mother substrate **90** is scribed by the upper substrate cutting device **60** and the lower substrate cutting device **70** along the Y direction. When it is necessary to scribe a plurality of scribing lines along the Y direction, one scribing line is formed, ant then the bonded mother substrate **90** is slid toward the substrate carry-in side by the clamp devices **251,** and then the bonded mother substrate **90** is slid toward the substrate carry-out side along the Y direction, thereby the next scribing line being formed.

[00396] When the formation of all the scribing lines along the Y direction is completed, the scribing is performed on the bonded mother substrate **90** along the X direction. When a plurality of scribing lines are formed along the X direction, the scribing lines are formed on the bonded mother substrate **90** along the X direction starting in turn from the side edge opposite to that clamped by the clamp devices **251.** Also in this case, the bonded mother substrate **90** is slid by the clamp members **51** along the Y direction while it is lifted from the timing belts by the first substrate floating units **29A** and the second substrate floating units **29B,** and the bonded mother substrate **90** is placed at the predetermined position with respect to the upper substrate cutting device **60** and the lower substrate cutting device **70.** The bonded mother substrate **90** is scribed along the X direction by the upper substrate cutting device **60** and the lower substrate cutting device **70** while the transportation by the clamp members **51** is stopped.

[00397] The bonded mother substrate **90** is in a state in which it is lifted from the timing belts when the scribing is performed in the X direction. Thus, a stopper **297** is, as shown in Figure **44,** provided between the first substrate floating units **29A** and the second substrate floating units **29B** on one side edge of the substrate supporting device **20** such that the bonded mother substrate **90** does not move due to the pressure by the upper substrate cutting device **60** and the lower substrate cutting device **70.**

[00398] The bonded mother substrate **90** is slid in the Y direction by the clamp devices **251** each time one scribing line is formed along the X direction, and thereafter, the formation of the scribing line is performed along the next X direction.

[00399] As described above, the bonded mother substrate **90** is scribed by the upper substrate cutting device **60** and the lower substrate cutting device **70** in a state in

which the bonded mother substrate **90** is lifted by the first substrate floating units **29A** and the second substrate floating units **29B** so as not contact the timing belts of the first substrate supporting units **244A** and the timing belts of the second substrate supporting units **244B.** Thus, there is no concern that the bonded mother substrate **90** is cut by being rubbed against the timing belts when the scribing is performed, thereby a stable scribing operation being performed.

[00400] When the entire scribing operation is completed, the bonded mother substrate **90** is slid in the Y direction by the clamp devices **251** so as to be placed above the timing belts of the second substrate supporting units **244B.** Thereafter, simultaneous to the stop of the gushing of the compressed air from the first substrate floating units **29A** and the second substrate floating units **29B** being stopped, the clamp members **51** are lowered. As a result, the bonded mother substrate **90**, for which the scribing is completed, is mounted on the timing belts of the second substrate supporting units **244B.**

[00401] In such a state, the clamping of the bonded mother substrate **90** by the clamp devices **251** is released, and then the timing belts of the second substrate supporting units **244B** are driven. As a result, the bonded mother substrate **90** mounted on the timing belts of the second substrate supporting units **244B** is transported to the carry-out side.

[00402] As described above, there is no concern that stress is applied to the bonded mother substrate **90** due to the ununiformity of the direction and level of each of the timing belts when the bonded mother substrate **90** is scribed. Furthermore, it is not necessary to synchronize the sliding of the bonded mother substrate by the clamp devices **251** and the circling of each of the timing belts. Yet furthermore, there is no concern that the stress is generated due to the contacting of the bonded mother

substrate **90** to each of the timing belts. Moreover, it is not necessary to synchronize the sliding speed of the bonded mother substrate **90** by the clamp devices **251** and the circling speed of each of the timing belts, thereby the controlling of the clamp devices **50** and each of timing belts being easy. Furthermore, when the bonded mother substrate **90** is slid by the clamp devices **251**, it is possible to reduce the driving force for the clamp devices **251** since the bonded mother substrate **90** is being lifted in the air.

[00403] The structure of the first substrate floating units **29A** and the second substrate floating units **29B** is not limited to that described above. For example, a structure of the first substrate floating units **29A** and the second substrate floating units **29B** can be made in which an air gushing opening is formed at the top surface of the table **291** or alternatively, the top surface of the table **291** is made of porous material. The air gushing opening is formed in a groove.

[00404] The way of carrying-in and carrying-out the substrate to the scribing position is not limited to timing belts. Other transportation means can be used.

[00405] Embodiments 1, 2 and 4 have a structure that the first substrate supporting section, the second substrate supporting section and the substrate cutting device guide are fixed to the mounting base and the clamp devices are movable in the Y direction. Alternatively, it is possible to have a structure in which the clamp devices are fixed to the mounting base and the first substrate supporting section, the second substrate supporting section and the substrate cutting device guide are movable in the Y direction. In any manner, a structure only has to be made such that the first substrate supporting section, the second substrate supporting section and the substrate cutting device guide move relative to the bonded mother substrate **90** gripped by the clamp devices.

INDUSTRIAL APPLICABILITY

[00406] According to the substrate cutting system of the present invention, the substrate supported by the first substrate supporting units and the second substrate supporting units is moved in the Y direction while being held by the clamp devices; the substrate being moved can be cut in the X direction from the upper surface side and the lower surface side of the substrate by the substrate cutting device; and then, the substrate supported by the first substrate supporting units and the second substrate supporting units is reciprocated in the Y direction while being held by the clamp devices; and the substrate being moved can be cut in the Y direction from the upper surface side and the lower surface side of the substrate by the substrate cutting device. Therefore, it is possible to continuously cut single-plate substrates of both top and bottom surfaces forming the bonded substrate in two directions perpendicular to each other in a horizontal direction without the bonded substrate being inverted in the up-and-down direction or being rotated by 90 degrees in the horizontal direction. Thus, the entire system becomes compact and it is possible to continuously process in two directions with one setting, such as positioning.